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MARCH-APRIL 2024

INVENTION INTELLIGENCE

NRDC Publication

Science Fiction and its Creators : some Reflections

Satyendra Nath Bose and his Contributions that Transformed Physics

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Department of Scientific and Industrial Research

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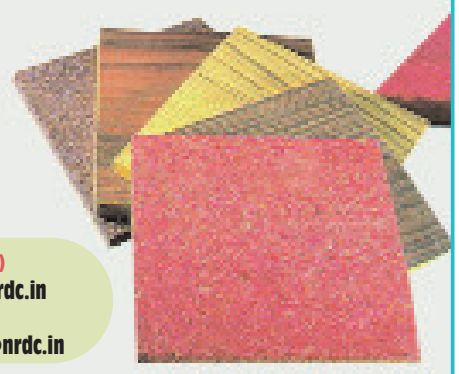

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From the Desk of CMD

Dear Readers!

We are aware that technology is evolving at a faster pace than ever before and emerging technologies like artificial intelligence are altering the role of technology in global economy. India's technological progress in the past decade has showcased a commitment to innovation and self reliance. From space explorations to defence capabilities and rapid advancements in the biomedical fields, the nation is competing with the world's technology landscape. Government policies and flagship programmes are playing a central role in shaping and supporting these innovations to help mitigate the global challenges like climate change, poverty and unemployment. The recent, India's National Deep Tech Start-up Policy was meticulously drafted to propel deep tech sector and seeks to ensure that the technology so developed is the best in the world.

The recently held India International Science Festival (IISF) displayed the objective of 'Science and Technology Public Outreach in *Amrit Kaal*'. Government is making all efforts in bringing a holistic technological innovation ecosystem by way of policy shifts towards space reforms through Public-Private Partnerships (PPP), the National Quantum Mission (NQM), Anusandhan-National Research Foundation (ANRF), National Geospatial Policy, National Education Policy (NEP) and reforms in the patent regime for smoother IP governance.

In line with the Indo-US technology and trade collaboration framework, an international symposium on 'Technology Transfer – Commercializing Intellectual Property for a Sustainable Future' was organised by NRDC in collaboration with the United States Patent and Trademark Office (USPTO); the Department for Promotion of Industry and Internal Trade (DPIIT), the Cell for Intellectual Property Promotion and Management (CIPAM); Karnataka State Council for Science and Technology (KSCST); and the Cambridge Institute of Technology (CIT) on 14 March 2024. It highlighted India's pivotal role to contrive, co-create, and collaborate to contribute meaningfully towards the protection and management of Intellectual Property Rights (IPR) and technology transfer of green technologies to address the common challenges in advancing the United Nations' Sustainable Development Goals (SDGs) across various sectors collectively though Indo-US strategic S&T collaborations.

We appreciate the commitment shown by the Indian Patent Office in strengthening the innovation ecosystem by introducing significant amendments to India's Patent Rules recently. The new amendments aim to stimulate patent filing by streamlining the process, strengthening the protection and aligning with the international standards. NRDC has made significant contribution to the latest achievement of the Indian Patent office, i.e. filing of over one lakh patents in 2023-24 through IPR awareness programmes and the Programme for Inspiring Inventors and Innovators (PIII). For leveraging innovation at the regional level, with the objective of achieving better reach out and public participation through collaboration, NRDC his joined hands with the Government of Odisha. We are sure this ecosystem will certainly make a significant impact and create opportunities for academia-industries collaboration and interaction in the region.

NRDC is bringing out this issue of *Invention Intelligence* with articles on Science Fiction and its Creators: some Reflections; Satyendra Nath Bose and his Contributions that Transformed Physics; HSR Transit Mode: India Enters the Bullet Train Era; Recent Developments in Biotechnology may Bring the Next Agricultural Revolution; YInMn Blue: A Long-Lasting Pigment for Blue Colour. I convey my best wishes for a successful publication of this issue of *Invention Intelligence*.

Jai Hind

Science Fiction and its Creators : Some Reflections

Dr. Subodh Mahanti

“In science fiction, we are always searching for new frontiers. We are drawn to the unknown.”

Ridley Scott (1937)
known for directing films in science fiction

“Science fiction frees you to go any place and examine anything.”

Octavia Estelle Butler (1947-2006)
a noted science fiction author

Science fiction, a genre of speculative fiction, can inspire to visualise many potential applications of scientific research and technical innovations, which are not even imagined by original researchers. It has been a source of inspiration for scientists and technologists since its inception. Science fiction is often referred to as literature of ideas. It acts as a catalyst for creativity and inquiry. It has motivated cutting-edge scientific research, inspired new technologies and changed how we view everyday life. It describes the potential consequences of scientific and technological innovations and contemplates alternate destinies. It serves as a window to peek into the possible future. It explores future discoveries and innovations. Science fiction is a literary genre, which represents change and tries to prepare the humankind to accept change, to view change as both natural and inevitable. It depicts tangible visions of probable future changes, for better or for worse. Its ability to predict future social and technological change makes it significant. It envisions different possibilities. It bridges past, present and future. Science fiction has established itself as a major influence on global culture and thought. The ever-greater relevance and vitality of science fiction is obvious. Science fiction has inspired many to pursue careers in science and which in turn has led to advancements in technology. Science fiction's content is imaginative but based in science. Its settings, characters and themes are guided by scientific facts, theories and principles. The present article briefly discusses various facets of science fiction including some of its founders. It also comments on Indian science fiction.

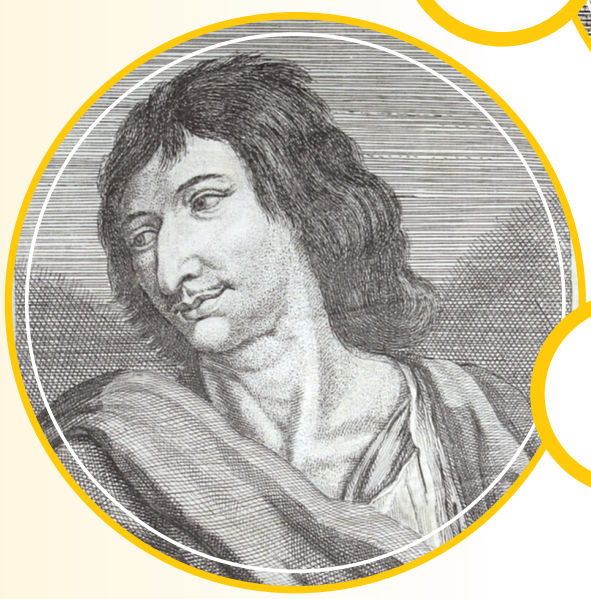
“**S**cience fiction is the most important literature in the history of the world, because it's the history of ideas, the history of our civilisation birthing itself”, said Ray Douglas Bradbury (1920-2012), a prominent science fiction writer of the 20th century. The American literary critic and theorist Robert Scholes (1929-2016) stated that the history of science fiction is "the history of humanity's changing attitude toward space and time…the history of our growing understanding of the universe and position of our species in that universe." Science fiction deals with an amazing variety of themes, namely, alien life forms, alternate reality, artificial gravity, artificial intelligence, asteroid mining, bionics, cryonics, cyborg, ecology, galactic empires, genetic engineering, psychology and mind control, mutants, nanotechnology, nuclear reactors, parallel universes, planetary and interstellar warfare, robots including humanoid robots, space colonisation, space travel and exploration, teleportation, time travel, virtual reality and so on. A number of existing technologies were first predicted in science fiction. For example: air-surface missiles, Android, bionic limbs, chemical weapons, cloning, computer virus, credit cards, drones, electric heating, fingerprint scanner, hologram, home automation, jet engine, laser, machine translation, military tanks, mobile phone, nuclear weapons, photography, remote-control devices, organ transplant, pocket calculator, printer, radio, remote control device, robots, self-driving car, smart phone, space station, submarine, television, and world wide web. French filmmaker Georges Melies's 1902 film *Le voyage dans la Lune (A Trip to the Moon)* was the first film to show lunar landing and it was inspired by Jules Verne's novels From the *Earth to the Moon* (1865) and *Around the Moon (1865)* as well as *The First Men* in *the Moon* (1901) by H.G. Wells.

Origin of science fiction

It has been reported that the term 'science fiction' first appeared in print in 1851. It appeared in Chapter 10 of William Wilson's *A Little Earnest Book Upon a Grand Old Subject* (see "Science Fiction: The Early History" by H. Bruce Franklin, hbrucefranklin.com). Hugo Gernsback is sometimes credited with coining the term 'science fiction' in 1929 (https://en.wikipedia.org). The website of BBC (bbc.co.uk) writes: "Gernsback later coins 'science fiction' in his magazine Science Wonder Stories in 1929." Jayant V. Narlikar, the famous Indian astrophysicist and a noted science fiction writer, credits John Campbell, the writer-turned-famous editor of *Astounding Stories*, for naming this type of literature as 'science fiction'. He wrote: "What is science fiction? There is no unique answer to this question…John Campbell, the man who named this type of literature as science fiction, had a somewhat broader scope in mind."

1 Lucian of Samosata

2 Cyrano de Bergerac



3 Jonathan Swift

4 Francis Bacon

5 Johannes Kepler

6 Voltair

(see *The Scientific Edge: The Indian Science from Vedic to Modern Times*, by Jayant V. Narlikar, Penguin Books, 2003). Isaac Asimov, in his *I. Asimov: A Memoir*, wrote: "One of the branches of pulp fiction was 'science fiction'– the smallest and least regarded branch. It came into being in the pulp world in the form of *Amazing Stories*, whose first issue appeared in April 1926. Its editor and, therefore, the founding father of magazine science fiction, Hugo Gernsback, called it 'scientifiction', an ugly portmanteau word. He was forced out as editor in 1929, and went on to found two competing magazines that summer, *Science Wonder Stories* and *Air Wonder Stories*, which were soon combined into *Wonder Stories*. In connection with these magazines, he first made use of the term 'science fiction'. The term 'speculative fiction', a term often associated with the science fiction genre, was first used by Robert A. Heinlein in 1947. The term 'sci-fi' was coined by Forrest James Ackerman (1916-2008), a leading expert on science fiction, in 1954. It appears that a consensus is yet to be achieved on who created the term 'science fiction' and when it was first used. However, it can be said with certainty that it was popularised in the 1920s by Hugo Gernsback, the editor of the first magazine established exclusively for science fiction.

What is science fiction? "The question 'what is science fiction?' has engaged the attention of many a critic and editor ever since the genre started holding on its own in the realm of literature. Even those luminaries who ruled the roost in an earlier era, like Edgar Allan Poe, William Wilson or Edgar Fawcet, had tried at providing a definition of what precisely constitutes science fiction" (Bal Phondke in his Preface to *It Happened Tomorrow*, National Book Trust, India, 1993). Hugo Gernsback, while defining science fiction or 'scientification' as he once termed this genre of literature, wrote: "By 'scientification', I mean the Jules Verne, H.G. Wells and Edgar Allan Poe type of story– a charming romance intermingled with scientific fact and prophetic vision." Barry N. Malzberg says, "Science fiction is that form of literature that deals with the effects of technological change in an imagined future, an alternative present or reconceived past" (en.wikipedia.org). According to Isaac Asimov science fiction is that branch of literature, which deals with human responses to changes in science and technology" ("What is Science Fiction?", https:/kinnu.xyz). There is no consensus on the definition of science fiction. The term 'science fiction' has been used with a variety of meaning for various forms of literature. Jayant V. Narlikar writes: "More permissive interpretations allow just about anything to be called science fiction, which explains why there is so much trash going under this genre with horror, black magic and fairy tales essentially hijacking the true spirit of science fiction. This demeaning feature is reflected in the Indian version also, though to a lesser extent."

As there is no single accepted definition of science fiction, there is no general consensus on what was the first science fiction story. Many ancient religious texts and epics in different cultures had themes, which were later found in science fictions albeit in different forms and tenor. But then as the *www.britannica.com* writes: "Science fiction is a modern genre.

Though writers in antiquity sometimes dealt with themes common to modern science fiction, their stories made no attempt at scientific and technological plausibility, the feature that distinguishes science fiction from earlier speculative writings and the contemporary speculative genre such as fantasy and horror." Many would like to think that science fiction has its beginnings at least as early as 2nd century CE. *A True Story* (it was originally written in Greek and it also translated as True History), a short novel written by the Syrian author Lucian of Samosata (born CE 120 and died after CE 180) had many features of modern science fiction, namely, travel to other worlds, extra terrestrial life forms, interplanetary warfare and artificial life. *New Atlantis* (1626) by Francis Bacon (1561-1626), *Somnium* (1634) by Johannes Kepler (1571-1630) and *Comical History of the States and Empires of the Moon* (1657) by Cyrano de Bergerac (1619-1655) are some examples of early science fiction. Jonathan Swift's (1667-1745) satirical novel *Gulliver's Travels* (1726) is considered by many as a significant precursor of modern science fiction novels. It has also been argued that the French enlightenment writer Voltaire (1694-1778) wrote the first science fiction story entitled Micromegas (1752) and he should be considered as first science fiction writer. In *Micromegas*, two aliens come to Earth– one from Saturn and the other from a planet circling a star

near Sirius. The two aliens explore the Earth and eventually they make contact.

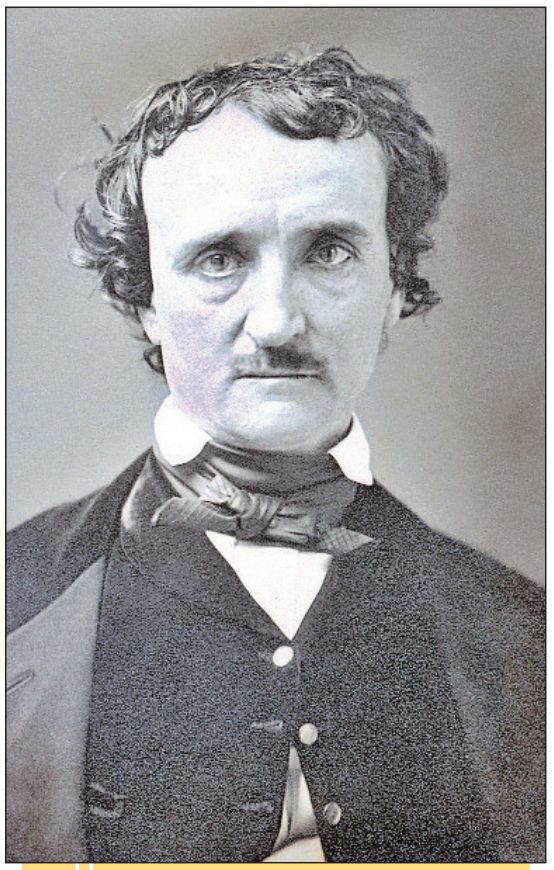
The period from 1938 to 1946 is recognised in the history of science fiction as the first Golden Age of Science Fiction, particularly in USA. The Golden Age, during which science fiction genre gained much public attention, followed the 'pulp era' of 1920s and 1930s. The 'pulp era' so named because in this period science fiction magazines were printed on cheap wood pulp paper. The style of science fiction developed in the 1960s and 1970s is identified as the New Wave of Science Fiction. The authors who created this genre freely experimented with the form and content of stories and they put greater emphasis on psychological and social sciences as opposed to physical sciences. They also incorporated the contemporary trendy styles of non-science fiction literature. Harlan Ellison's anthology *Dangerous Visions* (1967) is regarded as the early best example of this genre.

Pioneers of science fiction

Jules Verne and H.G. Wells are considered as founders or creators of science fiction. H.G. Wells is often called the 'father of science fiction'. Many critics regarded Wells as the 'Shakespeare of science fiction'. Edgar Allan Poe is also often named with Jules Verne and H.G. Wells as the founder of science fiction. Mary Wollstonecraft Shelley is also widely regarded as the one who started the genre. Hugo Gernsback is also often referred to as 'Father of Science Fiction'. Isaac Asimov, Arthur C. Clarke and Robert A. Heinlein are known as the 'Big Three' of science fiction.

Mary Wollstonecraft Shelly

- **Mary Wollstonecraft Shelley** (30 August 1797-1 February 1851) was an English Romantic novelist. She has been projected by her admirers as 'Mother of Science Fiction'. Shelley's *Frankenstein or, The Modern Prometheus* (1818) is regarded as a major step in the evolution of science fiction. Many think that her *Frankenstein* (1818) and *The Last Man* (1826) helped define the form of science fiction that we know today.
- **Edgar Allan Poe** (19 January 1809-7 October 1849) is considered as one of the earliest science fiction writers. His many works can be loosely classified as science fiction. Clarke Olney writes: "Edgar Allan Poe is generally acknowledged to be the father of modern mystery or detective story…What is perhaps not so widely recognised is that Poe was also the originator of a genre, which has come to rival the mystery story in popularity. It probably cannot be maintained that Poe intended to invent the science-fiction tale. But he was in effect doing so when he established standards for telling such stories, which have been accepted by most subsequent practitioners" ("Edgar Allan Poe – Science Fiction Pioneers" by Clarke Olney, *The Georgia Review*, Vol. 12, No. 4, pp. 416-421, 1958). He is regarded as a pioneer science fiction writer and he inspired many of those who followed him. The website of the National Park Service, USA, wrote: "Although fascinated with advances in science & technology, Poe was doubtful of humanity's progress via science…Despite his ambivalence towards science, Poe's experimentation with the themes of man's relationship to the universe



Edgar Allan Poe

clearly established him as one of the earliest science fiction writers. Later, famous science fiction writers such as Jules Verne, Arthur C. Clarke, and Isaac Asimov explores these same themes." ("Edgar Allan Poe Pioneers Science Fiction", www.nps.gov).

- **Jules Verne** (8 February 1828-24 March 1905) was a founder of science fiction. It has been said that he was the first authentic writer of modern science fiction. He is also called the 'prophet' of scientific progress. He was a science and technology enthusiast and he believed that progress in science and technology would result in the improvement of society and it would expand human potential. He has influenced generations of scientists, technologists, inventors, and explorers to push the boundaries. Among others Konstantin Tsiolkovsky (1857-1935), Guglielmo Marconi (1874-1937), Werner von Braun (1912-1977) and Yuri Gagarin (1934-1968), have acknowledged Verne's inspiration. Verne's father was a lawyer. Verne also studied law in Paris but at the same time he was writing and interacting with other authors and artists. He befriended Alexandre Dumas (1802-1870) and Victor Hugo (1802-1885), who had great influence on him. In 1852, Verne decided not to pursue law as career in favour of becoming a full-time professional writer. Verne's father put pressure on him to abandon his writing and become a lawyer. But Verne did not relent. He wrote to his father: "Am I not right to follow my own instincts? It is because I know who I am that I realise what I can be one day."

Jules Verne

Jules Verne wrote in French but he has a worldwide influence. He is one of the most translated authors in the world. His works have been translated into more than 140 languages. He is the second-most translated author in the world – he is preceded by Agatha Christie and followed by William Shakespeare. He wrote 54 novels under the series Voyages Extraordinaires including *Five Weeks in a Balloon* (1863), *Journey to the Centre of the Earth* (1864), From the Earth to the Moon (1865), *Around the Moon* (1865), *Twenty Thousand Leagues Under the Seas*, (1870), and *The Mysterious Island* (1875).

One of the most celebrated 20th century American science fiction writers, Ray Bradbury (1920-2012) said: "We are all, in one way or another, the children of Jules Verne" (www.wgbh.org). France celebrated the year 2005 as 'Jules Verne Year' on the occasion of his death centenary.

Herbert George Wells

- **Herbert George Wells** (21 September 1866-13 August 1946) is often called "the father of science fiction". He is the author of several enduring science fiction classics including *The Time Machine* (1895), *The Island of Doctor Moreau* (1896), *The Invisible Man* (1897), *The War of Worlds* (1898) and *The First Men in the Moon* (1901). He introduced several themes in the science fiction genre. Wells came from a poor family background. His parents were domestic servants, who later inherited a small shop but it was not a successful venture. He started working at the age of 14 but after receiving a scholarship he studied biology under T.H. Huxley at the Normal School of Science (later renamed as Royal College of Science, South Kensington). It was Huxley who introduced him with science fiction. In 1890, Wells obtained a Bachelor of Science degree in Zoology from the London University External Programme and became a school teacher. However, because of his ill-health he could not continue his job as

a school teacher. Wells' first published work was *A Text-Book of Biology* in two volumes (1893). Wells is primarily remembered for his pioneering contribution to the genre of science fiction but he made significant contributions in other areas too. He was a master of comedy, a political novelist and a social theorist. He was a futurist and a visionary. Wells thought his science fiction would make people's eyes and minds open to new ways of thinking. John Higgs, the author of *Stranger Than We Can Imagine: Making Sense of the Twentieth Century*, stated that in the late 19th century Wells "saw the coming century clearer than anyone else." Wells was nominated four times for Nobel Prize in Literature. Joseph Conrad, who was highly impressed by Wells' work, hailed him "O Realist of the Fantastic" (en.wikipedia.org). He co-founded the charity, The Diabetic Association (now known as Diabetes UK).

- **Hugo Gernsback** (16 August 1884-19 August 1967) was a Luxembourg-born American inventor, author, editor, and publisher. The American science fiction tradition is largely the creation of Gernsback. He is considered someone 'who invented science fiction'. He made pioneering contributions to the growth and development of the modern science fiction genre as publisher, editor, critic and writer.

Gernsback is somewhat a controversial figure in science fiction studies. Brian Wilson Aldiss (1925-2017), the author of the classic science fiction trilogy, the Heliconia trilogy, called Gernsback 'one of the worst disasters ever to hit science fiction.' Gary W. Westfahl (1951-), an American scholar of science fiction, writes: "As no one credibly deny, Hugo Gernsback was the man who launched this tradition (the science fiction tradition) and established its initial agenda, and some of his contributions are almost universally acknowledged: that he began publishing the first time, science fiction magazine, *Amazing Stories*, in 1926; that by means of skilled marketing and proselytising, he persuaded his readers, other publishers, and eventually the entire world in the existence of 'science fiction' as a distinct category of literature; that he brought previously separated people with an interest in science fiction together, both informally through his magazines' letter columns and formally by forming the first fan organisation, the Science Fiction League, and he thus set in motion the process that culminated in the vast scientific community that we observe today" (see Gary Westfahl, "The Popular Tradition of Science Fiction Criticism, 1926-1980", *Science Fiction Studies*, July 1999). He is also called the man who invented science fiction ("The Man who Invented Science Fiction– Hugo Gernsback" by Herald Sack, scihi.org).

Hugo Gernsback

Gernsback made pioneering contribution to the early development of radio. He was deeply associated with the amateur radio movement in USA. He played an instrumental role in establishing the Wireless Association of America. Gernsback helped establish a link between the amateur radio movement and science fiction and this in turn significantly influenced the ways American science fiction envisioned communication technology. He held more than 80 patents for radio and electronic devices.

- **Robert Anson Heinlein** (7 July 1907-8 May 1988) is considered one of the most influential writers in science fiction. He is often called 'dean of science fiction writers'

Robert A. Heinlein

("Remembering Robert A. Heinlein, the Dean of Science Fiction" by John Tomasino, sapl.org). He is regarded as a pioneer of the sub-genre of hard science fiction. He was among the first to emphasise scientific accuracy in his fiction, a pioneer of the hard science fiction sub-genre. He redrew the boundaries of science fiction. He was one of the 20th century's most popular science fiction writers. He wrote 32 novels and 59 stories. Some of his well–known works are: The Puppet Masters (1951), *The Year of the Jackpot* (1952), *Starship Troopers* (1959), *Stranger in a Strange Land* (1961) and *The Moon is a Harsh Mistress* (1966). His works are not free from controversies.

Several of Heinlein's works have been adopted for films and television shows. The 1950 film *Destination Moon*, which won an Oscar, was based on a Henlein's script. The film went on to inspire a new generation to become NASA engineers. He was the first recipient of the SFWA (Science Fiction and Fantasy Writers of America) Grand Master Award in 1975.

Arthur C. Clarke

Isaac Asimov

- **Arthur C. Clarke** (16 December 1917-19 March 2008) was one of the foremost science fiction writers of the 20th century. George Zebrowski (1945-), one of science fiction's most visionary authors, believed that "Clarke fulfilled the ambitions of science fiction (SF) in both, intellectual and artistic forms." He wrote about a hundred books and more than a thousand stories and other essays. He is best known for his Space Odyssey series—2001: *A Space Odyssey* (1968); 2010: *Odyssey Two* (1982); 2061: *Odyssey Three* (1987) and 3001: *The Final Odyssey* (1997).

In his article "Extra-terrestrial Relays" published in *Wireless World* (1945), he envisioned a communication satellite system that would relay radio and television signals throughout the world. He also suggested the idea of putting communications satellites in geostationary orbit. Clarke jointly with Stanley Kubrick wrote the screenplay for the 1968 film 2001: *A Space Odyssey*, one of the most influential films ever made.

He was the Chairman of the British Interplanetary Society, the oldest existing space advocacy organisation. In 1961, Clarke was awarded the UNESCO Kalinga Prize for science popularisation.

- **Isaac Asimov** (2 January 1920-6 April 1992) elevated the science fiction genre by incorporating elements of science, mathematics, sociology, and history in his works. His impact on science fiction is so pervasive that his name has become synonymous with it. He was a 20th century renaissance human. He is author of more than 400 books on a wide variety of subjects. Besides science fiction, he wrote books about Shakespeare, the Bible, American and world history, the history of math and chemistry, various branches of mathematics and science and literary criticism. His Foundation series and the Robot series books are among the most widely read science fiction. He is perhaps most well-known for his Three Laws of Robotics, 'which provide a moral ethical framework for the creation and interaction of robots and AI systems'. His science fiction significantly inspired the field of robotics. He was regarded an authority on science and science fiction alike. He was often called the Great Explainer because of his ability to make science understandable and interesting for the average reader, a process he called 'translating science'. On 2 January, which is the official

Types of science fiction

Historically, science fiction has been divided into two broad categories– hard science fiction and soft science fiction.

- **Hard science fiction:** The sub-genre of hard science fiction puts emphasis on scientific accuracy and logic. Isaac Asimov's *Foundation* (1951), Arthur C. Clarke's The Sentinel (a short science fiction story, 1951) and Hal Clement's *Mission of the Gravity* (1953) are early examples of hard science fiction sub-genre. The last one is regarded as early standard hard science fiction.
- **Soft science fiction:** This sub-genre of science fiction places greater emphasis on human aspects of the story. Marry Shelley's *Frankenstein* (1818), Robert A. Heinlein's *Stranger in a Strange Land* (1961) and Urusula K. Le Guin's *The Left Hand of Darkness* (1969) are early examples of soft science fiction. Science fiction has been further subdivided into different types or sub-genres. For example:
- **Dystopian science fiction:** A dystopian science fiction portrays a futuristic dark vision of the world. Yevgeny Zamyatin (1884-1937), Aldous Huxley (1894-1963) and George Orwell (1903-1950) produced the first dystopian science fictions. Zamyatin is regarded as the father of dystopian science fiction and his novel We (1924) is considered a classic dystopian science fiction novel and which was followed by Huxley's *Brave New World* (1932) and Orwell's *Nineteen Eighty-Four* (1949).
- **Utopian science fiction:** A utopian science fiction is set in a perfect world, which is often an improved version of the real one. Men Like Gods (H.G Wells, 1923), Andromeda (Ivan Yefremov, 1957), Pacific Edge (Kim Stanley Robinson, 1990) and Pandora's Star (Peter F. Hamilton, 2004) are examples of utopian science fiction.
- **Military science fiction:** This sub-genre combines elements of science fiction with military themes. *The War of the Worlds* (H.G Wells, 1898), *Starship Troopers* (Robert A. Heinlein, 1959) and *Legend of the Galactic Heroes,* a 10-volume series of epic science fiction novels (Yoshiki Tanaka, 1982-87) are examples of military science fiction.
- **Alternate history science fiction:** In alternate history science fiction, a fictional world is created in which a past action or event is introduced to change the known course of history. *The Man in the High Castle* (Philip K. Dick 1962), *The Calculating Stars* (Mary Robinette Kowal, 2018), and *The Oppenheimer Alternative* (Robert J. Sawyer, 2020) are examples of alternate history science fiction.
- **Cyberpunk:** This sub-genre of science fiction is noted for its focus on 'high technology and low life'. The word 'cyberpunk' was coined by the American science fiction author Bruce Bethke (1955-) in 1982. He wrote a story titled 'Cyberpunk'. The word is derived from the combination of 'cybernetics' and 'punk'. It is characterised by advanced technology particularly in computers and the internet. Some examples of novels written under this sub-genre are: *Do Androids Dream of Electric Sheep?* (Philip K. Dick, 1968), *China 2185* (Cixin Liu, 1989), *Neuromancer* (William Gibson, 1984), *Infomocracy: Book One of the Centenal Cycle* (Malka Ann Older, 2016) and *The Quantum Thief* (Hannu Rajaniemi, 2010).

There are many other sub-genres of science fiction including Steampunk, Biopunk, Nanopunk, Apocalaptic/ Post-apocalaptic and Mundane Science Fiction.

birthday of Asimov, National Science Fiction Day is unofficially celebrated in USA and some other countries including India.

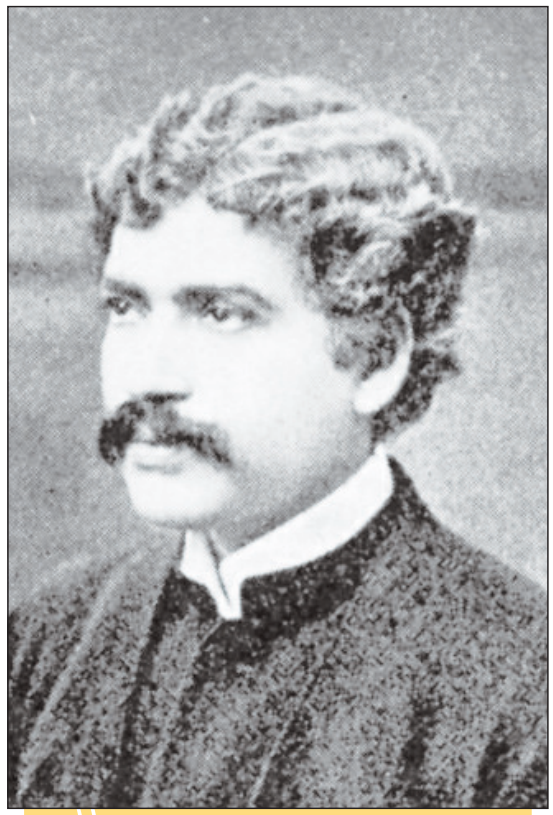
Awards and recognitions in the world of science fiction

The two of the most prestigious awards in science fiction are undoubtedly the Hugos and the Nebulas. There are many other awards including the Locus award.

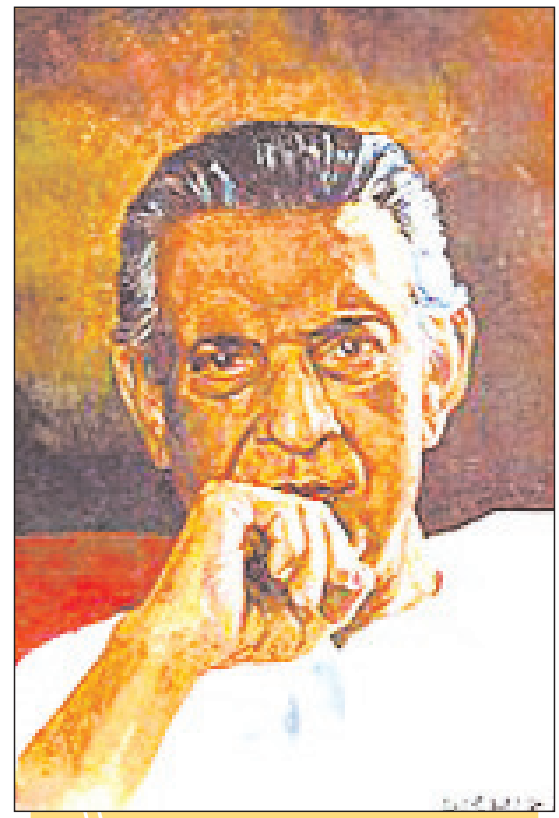
The annual awards presented in different categories at the World Science Fiction Convention are named Hugo Awards in the honour of Hugo Gernsback. Hugo awards are called the Oscars of the science fiction world.

The Nebula Awards were started in 1965 by the Science Fiction and Fantasy Writers of America. The Locus Awards, established in 1971, are an annual set of awards voted on by readers of the American science fiction and fantasy magazine Locus (founded in 1967). The Galaxy Award (China) is the highest award of Chinese science fiction.

Alfred Bester (1913-1987) won the First Hugo Award for Best Novel for his novel *The Demolished* in 1953. Orson Scott Card (1951-) is the first person to win the Hugo Award for Best Novel twice in a row. He is often considered as the voice of modern science fiction writers. Nora Keita Jemisin (1972-) is the first author to win Hugo Awards for Best Novel in three consecutive years (2015-2017).



Jagadish Chandra Bose



Satyajit Ray

J. V. Narlikar

She is also the first author to win Hugo Awards for all three novels in a trilogy–*The Fifth Sean, The Obelisk Gate* and *The Stone Sky of the Broken Earth* Series. She also won a fourth Hugo Award for Best Novella in 2020 for Emergency Skin. Robert A. Heinlein has won the most Hugo Awards for best novel– four Hugo Awards and two Retro Hugo Awards. He also received most nominations for Hugo Award –12 times.

In 2016, the Chinese science fiction writer Hao Jingfang (1984-) won the Hugo Award for Best Novella for her Folding Beijing (published in 2012). The Chinese computer engineer and science fiction writer Liu Cixin (1963-) won the 2015 Hugo Award for Best Novel for his novel The *Three Body Problem.* He is the first Asian to win the Hugo Award for Best Novel. He has won nine times the Chinese Galaxy Award.

Indian science fiction writer Mimi (Monidipa) Mondal and her co-editor Alexandra Pierce were nominated for the 2018 Hugo Award for Best Non-Related Category for their work *Luminescent Threads: Connections to Octavia E. Butler.* Their work received the Locus Award for Best Non-fiction on 22 June 2018.

Mondal's novelette His Footsteps, *Through Darkness* and *Light* was nominated for Nebula Award in 2020. Gautam Bhatia of India along with seven editors and staff of the *Strange Horizons* magazine was nominated for Hugo Award for the Best Semiprozine (short for semi-professional magazine) category in 2018. Indian engineer turned science fiction writer S. B. Divya (Divya Srinivasan Bree) was the first Indian to get nomination for the Nebula Award for Best Novel category (2021) for her novel *Machinehood*. The American science fiction writer Ted Chiang (1967-) is one of the most-honoured writers in contemporary science fiction. He has received four Hugo awards, four Nebula awards, six Locus awards and the John W. Campbell Award for Best New Writer.

The Grand Master Award, a life-time honour, is given annually by the Science Fiction and Fantasy Writers Association of USA to a writer of fantasy or science fiction. Robert Heinlein was the first person to receive this award in 1975. The award was renamed in 2002 as the Damon Knight Memorial Grand Master Award.

The Science Fiction Hall of Fame was established in 1996 by the Kansas City Science Fiction and Fantasy Society and the Centre for the Study of Science Fiction at the University of Kansas.

In 2021, Great Britain's Royal Mail issued illustrated stamps for six classic science fiction novels–Frankenstein (Mary Shelley), *The Time Machine*

Science fiction in India

Indian science fiction has evolved over the years and gradually it is creating a space for itself on the global scene. Sami Ahmad Khan says: "There exists more than a century of 'modern' Indian SF. To cite from two languages: Hindi has Pandit Ambika Dutt Vyas's 'Ascharya Vrittant' published in *Piyush Pravaha* (1884), Babu Keshav Prasad's 'Chandra Lok Ki Yatra' published in *Saraswati* (1900) and Bengali has Hemlal Dutta's 'Rahasya' published in *Vigyan Darpan* (1882), Jagadananda Ray's *'Shukra Brahman'* (1892), and Jagadish Chandra Bose's 'Palatak Toofan' published in Avyakta (1896)'. (Quoted from "How to Explicate Indian Science Fiction? The IN-situ Model" by Sami Ahmad Khan, www.thebeacon.in).

Some of the publications on different facets of Indian science fiction are:

1. *It Happened Tomorrow* (This anthology of 19 select stories written in different Indian languages presents the trend in Indian science fiction), edited by Bal Phondke, National Book Trust, India, 1993.
2. *The Scientific Edge: The Indian Scientist from Vedic to Modern Times* by Jayant V. Narlikar, Penguin Books India, 2003. The third part of this book has a small section titled 'Indian Science Fiction'.
3. *Science Fiction in Colonial India, 1835-1905: Five Stories of Speculation, Resistance* and Rebellion, edited by Mary Ellis Gibson, Anthem Press, 2019.
4. *The Gollanze Book of South Asian Science Fiction,* edited by Tarun K. Saint, Hachette India, 2019.
5. *Indian Science Fiction: Patterns, History and Hybridity* by Suparno Banerjee, University of Wales Press, 2020.
6. *Science Fiction and Indian Women Writers: Exploring Radical Potentials,* by Urvashi Kuhad, Routledge, 2022.
7. *Science Fiction in India: Parallel Worlds and Postcolonial Paradigms*, edited by Shweta Khilnani and Ritwick Bhattacharjee, Bloomsbury Academic India, 2022.
8. *Vigyan Katha Kosh* (Dictionary of Science Fiction) Vol 1-6, edited by Santosh Choubey, Shukdev Prasad and Mohan Sagoria, AISECT Publications, Bhopal, 2022. The introduction to the series titled 'Vigyan Kathaon Ka Adbhut Sansar' ('Wonderful World of Science Fiction') is written by its Chief Editor, Santosh Choubey.

Commenting on Indian science fiction, J.V. Narlikar wrote: "In 1897 the famous Bengali scientist Jagadish Chandra Bose wrote one of the earliest sci-fi stories, 'The Taming of Storm'. Around the same time S.B. Ranade in Maharashtra wrote a Marathi science fiction story called 'Tarache Hasya' ('Laughter of Tara'). Since then Bengali and Marathi have led the field in Indian science fiction. More recently Satyajit Ray has led the way in writing science fiction in Bengali." Jagadish Chandra Bose's story was originally published in 1896 with the title 'Niruddesher Kahini' ('The Story of Missing One') and later expanded and added to his collection *Abyakta* in 1921 with the new title 'Palatak Toofan'. It may be noted that J.V. Narlikar has made significant contribution to Indian science fiction. The journey of modern Indian science fiction started more than 125 years ago. In recent years it has grown at a much faster rate than in the past. It is also diversifying. We need to assess its strengths and weaknesses. Bal Phondke wrote: "What is needed is cross-fertilisation of the Indian offerings with the fare the world at large has to offer. For that to occur, an introspective look at the entire spectrum of Indian science fiction would have to be resorted to, so the strengths are recognised and weaknesses identified."

(H.G. Wells), *New Brave World* (Aldous Huxley), *The Day of the Triffids* (John Wyndham), Childhood's End (Arthur C. Clarke) and *Shikasta* (Doris Lessing). The year 2021 marked the 75th anniversary of the death of H.G. Wells.

Conclusion

Science fiction is a continually evolving genre of literature. It is getting more and more diverse. Someone has termed it a 'travelling genre'. It is a genre rich with immense possibilities. The science fiction is often projected as a mirror for the future of humankind. Alastair Reynolds (1966-), the author of the Revelation Space series, says: "Science fiction can tell us what research will lead to. It can tell us what kind of societies what kind of lives, we are shaping. It can tell us about the use of science, about conscience and ethics and the larger purpose and vision behind discoveries, which are important incentives in making such discoveries. It also tells us about the vast inequities between those who benefit from scientific advances and those left behind."

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New Delhi 110078
E-mail: subodhmahanti@gmail.com

Satyendra Nath Bose and his Contributions that Transformed Physics

Dr. Punit Kumar

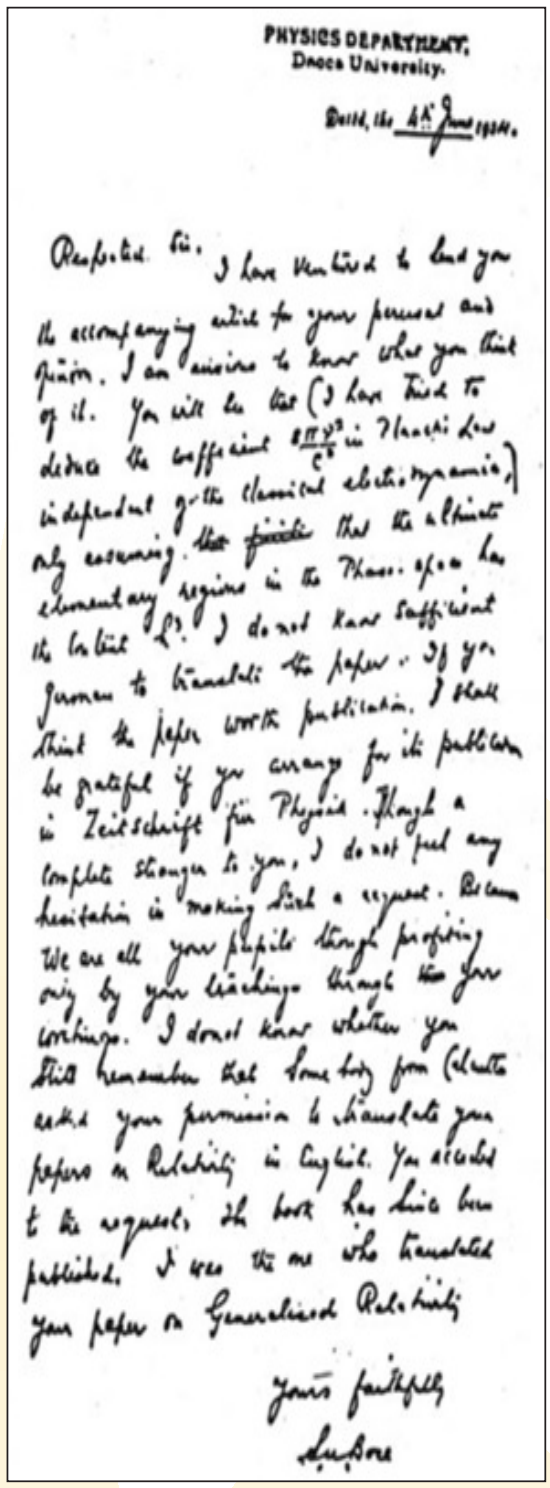
In the pages of scientific history, few names shine as brightly as Satyendra Nath Bose, an Indian physicist whose revolutionary contributions to theoretical physics have left an enduring impact on our comprehension of the universe. In the realm of scientific advancements, the year 1924 emerges as a crucial juncture when Satyendra Nath Bose presented an influential paper that transformed the landscape of theoretical physics. His seminal work not only questioned the established norms, but also established the groundwork for an entirely new understanding of particle behaviour. During a period when quantum mechanics was still in its early stages, Bose's acclaimed paper, titled 'Planck's law and hypothesis of light quanta', marked a pivotal moment in the field. Bose's research garnered the attention of none other than Albert Einstein, leading to a collaboration that birthed the groundbreaking theory now recognised as Bose-Einstein statistics.

Satyendra Nath Bose

Born on 1 January 1894 in Calcutta (now Kolkata), Bose was the eldest among seven siblings in a Bengali Kayastha family. Being the sole son, he had six sisters following him. His ancestral home was in the village of Bara Jagulia, located in the Nadia district of the Bengal Presidency. Bose's educational journey commenced at the age of five, close to his home. After his family relocated to Goabagan, he enrolled in the New Indian School. In his concluding year of school, he gained admission to the Hindu School. Successfully passing his matriculation exams in 1909, Bose secured the fifth position in order of merit. Subsequently, he pursued the

intermediate in science course at the Presidency College, Calcutta, where his mentors included Jagadish Chandra Bose, Sarada Prasanna Das, and Prafulla Chandra Ray.

Bose attained Bachelor of Science in Mathematics from Presidency College in 1913, securing the first position, while his fellow student and future astrophysicist Meghnad Saha came second. He then got enrolled in Sir Ashutosh Mukherjee's newly established Science College, where he once again achieved the top position in the M.Sc. examination in 1915. His performance in the M.Sc. examination set a new record in the history of the University of Calcutta. Following the completion of his M.Sc., Bose joined


PHYSICS DEPARTMENT,
Dacca University.

Dated, the 4th June 1924.

Respected Sir,

I have ventured to send you the accompanying article for your perusal and opinion. I am anxious to know what you think of it. You will see that I have tried to deduce the coefficient $8\pi\nu^2/c^3$ in Planck's law independent of the classical electrodynamics only assuming that the ultimate elementary regions in the phase space has the content h3. I do not know sufficient German to translate the paper. If you think the paper worth publication, I shall be grateful if you arrange its publication in Zeitschrift für Physik. ...Though a complete stranger to you, I do not feel any hesitation in making such a request. Because we are all your pupils though profiting only by your teachings through your writings. . . .

Yours faithfully,
S. N. Bose

S.N. Bose's letter to Albert Einstein

Respected Sir,
"I have ventured to send you the accompanying article for your perusal and opinion. I am anxious to know what you think of it. You will see that I have tried to deduce the coefficient $8\pi\nu^2/c^3$ in Planck's law independent of the classical electrodynamics only assuming that the ultimate elementary regions in the phase space has the content h3. I do not know sufficient German to translate the paper. If you think the paper worth publication, I shall be grateful if you arrange its publication in Zeitschrift für Physik. ...Though a complete stranger to you, I do not feel any hesitation in making such a request. Because we are all your pupils though profiting only by your teachings through your writings. . . ."

Yours faithfully,
S. N. Bose

the Science College, Calcutta, as a research scholar in 1916, initiating his studies in the theory of relativity during an exciting era of scientific progress. Quantum theory had just emerged on the horizon, and notable results were beginning to unfold.

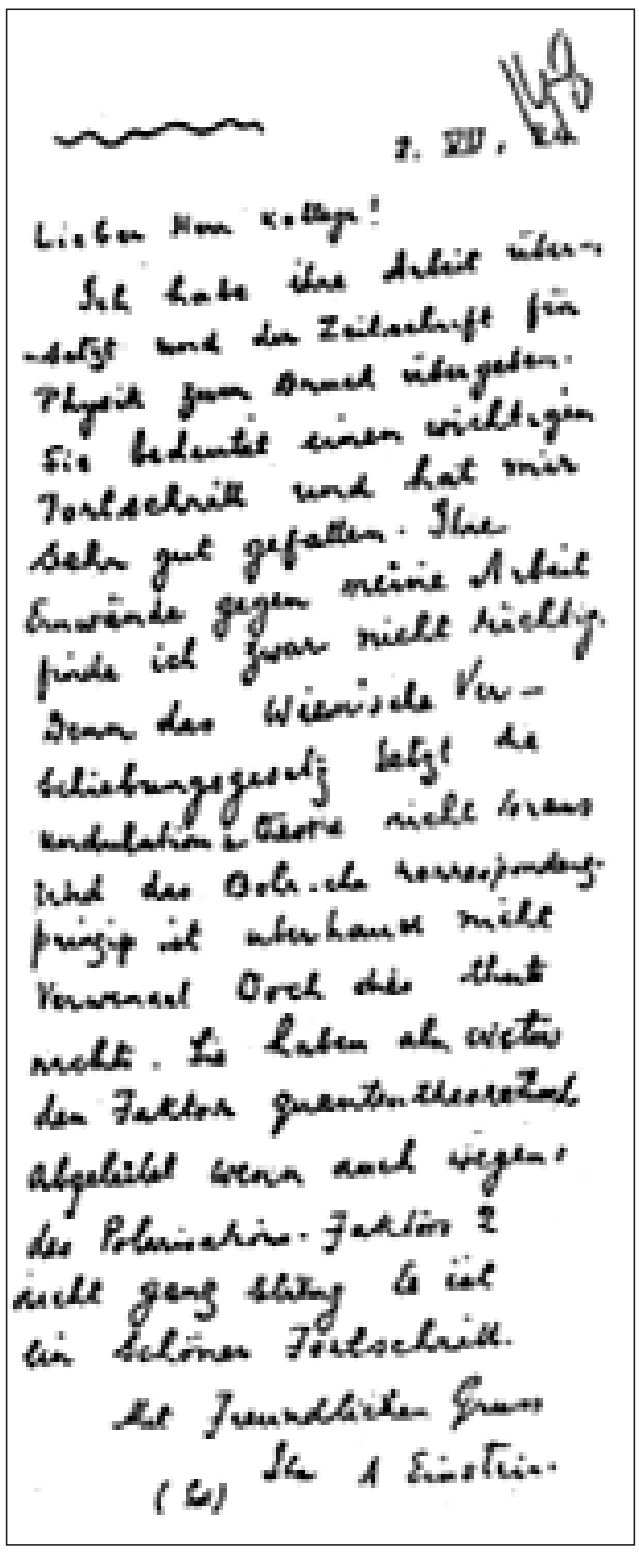
Bose's initial significant contribution to theoretical physics came through a collaborative research paper with Saha titled 'On the influence of the finite volume of molecules on the equation of state', published in the *Philosophical Magazine* in 1918. In the subsequent year, Bose authored two papers in the bulletin of the Calcutta Mathematical Society. One focussed on 'The stress equation of equilibrium', and the other on 'Horpolhod'. Both these papers delved into pure mathematics. In 1920, he collaborated with Saha again on a paper about the equation of state in *the Philosophical Magazine*. Following this, Bose presented his paper 'On the deduction of Rydberg's law from the quantum theory of spectral emission' in 1920, which was also published in *the Philosophical Magazine*. Subsequently, there were no publications from Bose for next three years.

While instructing post-graduate students at Dhaka University, Bose found dissatisfaction with the existing derivations of Planck's radiation law. Motivated by discussions with Saha, Bose developed a logically satisfying derivation grounded entirely in Einstein's photon concept. He successfully derived Planck's quantum radiation law without any reliance on classical physics, employing a novel method of counting states with identical particles. This paper played a pivotal role in establishing the significant field of quantum statistics. Despite submitting the paper to *the Philosophical Magazine*, it faced disappointment as it was turned down. However, not discouraged, Bose directly sent the article to Albert Einstein in Germany, accompanied by a covering letter, which read:

Einstein's reply came in a postcard dated 2 July 1924 on which he wrote, "I have translated your paper and given

it to Zeitschrift für Physik for publication. It signifies an important step forward and pleases me very much."

Einstein, acknowledging the significance of the paper, personally translated it into German and submitted it on Bose's behalf to the Zeitschrift für Physik, which published it in 1924. This recognition allowed Bose to work for two years in European X-ray and crystallography



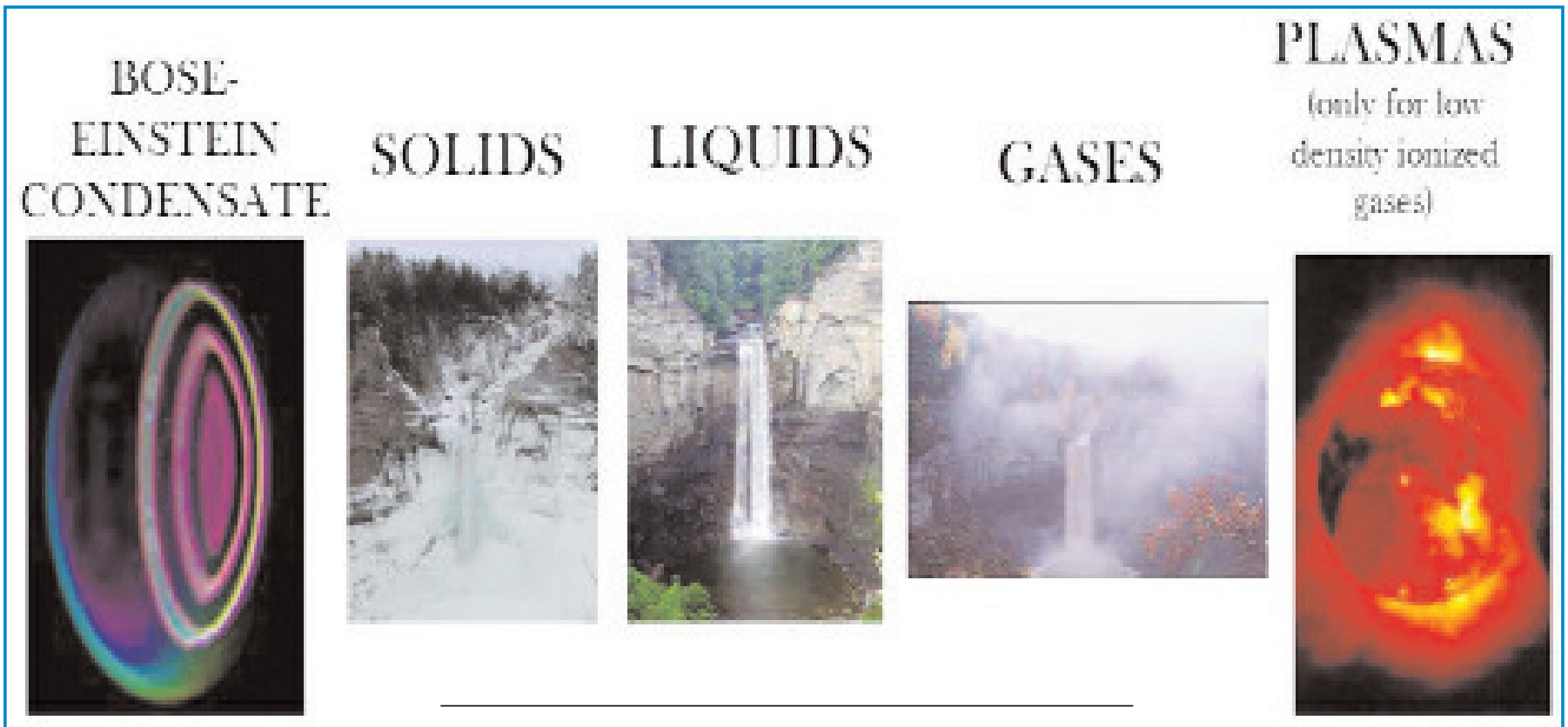
Einstein's reply to S.N. Bose

laboratories, collaborating with Louis de Broglie, Marie Curie, and Einstein. Einstein further expanded Bose's ideas into two additional papers. Their collaborative efforts gave rise to the concept of a Bose gas, governed by Bose-Einstein statistics, describing the statistical distribution of identical particles with integer spin, now known as Bosons. This statistical framework played a crucial role in understanding particle behaviour at temperatures approaching absolute zero. It elucidated how certain particles, bosons, could occupy the same quantum state, leading to the groundbreaking prediction of Bose-Einstein condensation (BEC). This phenomenon suggested a state where a macroscopic number of particles occupy the same lowest energy state. More broadly, condensation refers to the macroscopic occupation of one or several states, as seen in BCS theory where a superconductor is a condensate of Cooper pairs. This phenomenon has been experimentally observed and validated, contributing to the advancement of new technologies and enhancing our understanding of quantum mechanics.

JILA's Carl Wieman (University of Colorado, Boulder) and Eric Cornell (NIST) initiated the search for a BEC around 1990 using a combination of laser and magnetic cooling apparatus. The world's first BEC was achieved at 10:54 AM on 5 June 1995, in a JILA laboratory, a joint institute of the University of Colorado, Boulder, and NIST. The BEC formed inside a carrot-sized glass cell, visible through a video camera, measuring about 20 microns in diameter, or approximately one-fifth the thickness of a sheet of paper. The result was a BEC comprising about 2,000 Rubidium atoms that lasted for 15-20 seconds. Subsequently, Wolfgang Ketterle also achieved a BEC in his MIT laboratory.

Presently, scientists can produce condensates with significantly larger numbers of atoms, lasting as long as three full minutes, leading to continuous exploration of this unique form of matter. By September 2001, over three dozen other laboratories had successfully replicated the discovery. In 1997, MIT researchers devised an atom laser based on BECs, allowing the dripping of single atoms downward from a micro spout. In February 1999, a Harvard University team utilised a BEC to decelerate light to just 38 MPH by shining a laser beam through the condensate. Two years later, the team announced briefly bringing light to a complete stop. In March 1999, scientists at the NIST facility in Gaithersburg, MD, manipulated super cold atoms into a beam, creating a device capable of emitting streams of atoms in any direction. This breakthrough could potentially lead to a new technique for producing very small computer chips or constructing nano-devices.

Cornell, Ketterle, and Wieman were jointly awarded the 2001 Nobel Prize in Physics for their achievement. The Royal Swedish Academy of Sciences emphasised in the citation that their collective discovery of the BEC is poised to bring revolutionary applications in fields such as precision measurement and nanotechnology. The apparatus employed by the JILA team is now a permanent part of the Smithsonian Institute's collection in Washington, DC.



S.N. Bose was nominated multiple times for the Nobel Prize in Physics, recognising his contributions to Bose-Einstein Statistics. Despite several Nobel Prizes being awarded for research related to Boson concepts, Bose-Einstein statistics, and Bose-Einstein condensate, Bose himself did not receive the Nobel Prize. In 1954, he was honoured with the Padma Vibhushan, one of India's highest civilian awards, and in 1958, Bose became a Fellow of the Royal Society. In 1959, he attained the prestigious position of National Professor, the highest honour for a scholar in the country, holding the position for 15 years. The S.N. Bose National Centre for Basic Sciences was established in 1986 by an Act of Parliament, at Salt Lake, Calcutta. Bose assumed an advisory role in the newly formed Council of Scientific and Industrial Research. He served as the president of the Indian Physical Society and the National Institute of Science, and he was elected the General President of the Indian Science Congress. Additionally, Bose held positions as the Vice President and later the President of the Indian Statistical Institute. He was also nominated as a member of the Rajya Sabha. Bose's groundbreaking work significantly contributed to the foundation of quantum mechanics. The statistical methods he developed offered a theoretical framework for comprehending the properties and interactions of particles, thereby enriching the broader understanding of quantum theory. His contributions played a pivotal role in bridging the gap between classical and quantum physics, setting the stage for subsequent advancements in the field. Bose's work laid the foundation for numerous breakthroughs in modern physics, and the principles and concepts he introduced remain fundamental to the comprehension of particle physics, condensed matter physics, and quantum field theory.

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India's first bullet train will run between Mumbai and Ahmedabad covering a total line stretch of 508 kilometre (km). A 50 kilometre long section of this line, between Surat and Bilimora, is expected to start in June-July 2026, and the total stretch is expected to be completed by 2028. The history of the bullet train, its benefits and the bullet train project in India have been discussed in detail in the article.

The Mumbai-Ahmedabad bullet train of India based on E5 series Shinkansen of Japan (Courtesy: Wikipedia)

HSR Transit Mode: India Enters the Bullet Train Era

Dr. P.K. Mukherjee

With a line stretch of 508 kilometre, India's first bullet train will run between Mumbai and Ahmedabad with an operational speed of 320 kilometre per hour. A section of 50 kilometre of this line, between Surat and Bilimora, is expected to start in June-July 2026 in Gujarat, and the entire stretch will be completed by 2028, according to the Ministry of Railways. Besides Mumbai-Ahmedabad bullet train corridor, seven more corridors are in the pipeline.India's first bullet train terminal was built at Sabarmati Multimodal Transport Hub in Ahmedabad. The video of this terminal was unveiled by the Railway Minister on 7 December 2023.

Sharing the video on the micro blogging site X (formerly Twitter), the Railway Minister wrote in the caption to his post: Terminal for India's first bullet train– Sabarmati Multimodal Transport Hub, Ahmedabad. The spectacular scene of the bullet train station can be seen in the video, which showcases a captivating glimpse of the modern-day architecture clubbed with the cultural heritage of India. The station's building displays a large mural made with stainless steel in the south side, which depicts the historical Dandi March or Salt Satyagraha, a non-violent movement of Mahatma Gandhi against the British, carried out in the year 1931 in Gujarat. The Dandi March is also the theme of the Sabarmati station.

With a total area of around 1,13,000 square metres, the hub building has been constructed as a twin structure with space earmarked for offices, commercial development and retail outlets for passengers. Many people are getting awe-struck looking at the glorious structure of the station that is a blend of modernity and our cultural heritage. The first phase of India's bullet train project will hopefully be

Sabarmati multimodal transport hub, the first bullet train terminal of India at Ahmedabad

Bandra Kurla Complex (BKC), the first railway station of Mumbai-Ahmedabad bullet train

completed by 2026 while the project in toto is expected to be completed by 2028.

The work on the first phase of India's bullet train is in progress. For the first phase, laying of 508–kilometre long railway line with 12 stations, on which will run the first Indian bullet train between Ahmedabad and Mumbai, is being done. Of the total stretch of 508 kilometre, 465 kilometre would be elevated, 26 kilometre will run in tunnels, another 10 kilometre on bridges and 7 kilometre on embankment.

Of the 26 kilometre long track in tunnels, 5 kilometre will be under hills and 21 kilometre long track will run between Bandra Kurla Complex (BKC) and Shilphata in Maharashtra. For constructing 16 kilometre length of the tunnel, three tunnel boring machines are being used; and the remaining 5 kilometre length of the tunnel is under construction using an Australian method, called New Australian Tunnelling Method (NATM). Of the 21 kilometre long tunnel, 7 kilometre length is being constructed under the sea at Thane Creek, situated at the inter-tidal zone. This is the first undersea rail tunnel in India. It will consist of a single tube accommodating twin tracks for both up and down trains. The depth of the tunnel will be between 25 metre and 65 metre below the ground level with the deepest point being 114 metre below Parsik hill.

One of the largest tunnel boring machines in India will be utilised for the bullet train project, featuring a cutter head with a diameter of 13.1 metre. It may be remarked that urban tunnels used in metro system typically utilise cutter heads with diameter of 5-6 metre. According to the Department of Railways, due care is being taken of nature and environment in the construction of tunnels for the bullet train project. The birds' sanctuary situated near Thane Creek will not be affected by tunnel construction. Even the mangroves would not be removed during the construction process of the tunnel. The undersea tunnel will witness running of bullet train with a phenomenal speed of 350 kilometre per hour. The much publicised bullet train or high speed rail (HSR) project of the country will have Bandra Kurla Complex (BKC) as the only underground station. However, despite being underground, it will always be lit with natural light.

Everybody is anxiously waiting for the maiden run of the country's bullet train. However, besides the first Mumbai-Ahmedabad line, seven more HSR projects are in the pipeline, which are currently passing through

History of bullet trains

The construction and operation of the first bullet train of the world took place in Japan. Actually, bullet train is the literal translation of the Japanese word 'dangan ressha.' It is relevant to know that the first discussion about bullet train at conceptual level happened to take place in Japan in the 1930s. The bullet train nomenclature came to the fore due to the front portion (nose) of the train resembling bullet and its speed virtually matching the speed of the bullet. However, the bullet train in Japan was given the name Shinkansen, which means 'new trunk line' or 'new main line.' This name was first formally used in 1940 for a proposed standard gauge passenger and freight line between Tokyo and Shimonoseki. Let us have a look into the development of the original bullet train Shinkansen, known today as 0-(zero-) series Shinkansen. Proposed plan for the 0-series, in fact, dates back as far as the 1930s, and some construction was started in the 1940s. However, due to World War II, construction was halted. It was then somewhat forgotten. Only near the end of the 1950s was it that Japan resumed its construction. This was done to alleviate passenger traffic from conventional lines that were already moving at full capacity. However, a more important reason behind the construction was the upcoming 1964 Tokyo Olympics for which it was used as a prestigious project. It may be remarked that the modern designs of Shinkansen have dropped the bullet-nosed appearance. The last of 0-series Shinkansen were retired on 30 November 2008. Although the term bullet train quickly fell out of favour in Japan, abroad the name bullet train lives on even today. The credit of construction of the first bullet train in Japan goes to the Japanese engineer Hideo Shima (1901-1998). However, the first chairman of Japanese National Railways (JNR) Shinji Sogo has also an important role in it. The underlying idea behind the construction of bullet train was to develop a high-speed world-class intercity train network that would serve as an efficient public transportation system. As high class technological development, Japan succeeded in the construction of its first bullet train just before the Tokyo Olympics. On 1 October 1964, 'Tokaido Shinkansen' started its service. While the conventional express service was taking 6 hours and 40 minutes time to cover the distance between Tokyo and Osaka, Tokaido Shinkensen covered the same distance in barely 4 hours. By the year 1965, the travel time had been reduced to just 3 hours and 10 minutes. The greatest benefit of the bullet train was that it made day-time journey possible between two major cities of Japan. This not only benefitted the trading community but also the public at large. In this way, the bullet train was instrumental in bringing about a significant change in the lives of common Japanese folk. The bullet train enjoyed tremendous success and its demand kept on increasing rapidly. On 13 July 1967, even before completing three years of its debut run, it serviced 100 million (10 crore) passengers. Currently, the fastest bullet train operating in Japan is Nozomi running between Shin-Osaka and Hakata stations with an average speed of 300 kilometre per hour.

different planning stages.

Bullet trains have many benefits. However, before discussing them and the nitty-gritty of the Indian bullet train project, let us be seized of the history of bullet trains.

Advantages of bullet train

Besides Japan, bullet train runs in other developed countries too. The bullet trains have played a vital role in achieving regional integration world-wide and creating socio-economical balance in societies. By providing a high-speed mode of commuting between cities, bullet trains have fulfilled a very important need of people. Bullet trains have made transportation possible to major financial hubs, busy city centres and heritage cities. This has proved beneficial not only for the trading class but for the general public too.

In addition to the benefits of bullet trains to the trading community and public at large, bullet trains have also great benefits for the environment. It is estimated that generation of carbon emissions over the word's HSRs is one-third compared to car travel and

Bullet train project in India

The Indian Railways is regarded as one of the biggest railway networks in the world. There are a few trains in India, which have a running speed of 150 kilometre per hour or even more. Mention may be made of Shatabdi Express (150 kilometre per hour), Vande Bharat Express (180 kilometre per hour) and Gatimaan Express (160 kilometre per hour). Currently, these trains are fastest trains in India, running with great efficacy and safety standards. But with the need of more advanced and time-saving rapid transit mode of transport, Indian government signed a Memorandum of Understanding (MoU) with the Japanese government in 2016 to implement the first bullet train project in India that was named Mumbai-Ahmedabad High Speed Rail Corridor (MAHSR, 508 km). The foundation stone of this project was laid by the Prime Minister Shri Narendra Modi and the then Japanese Prime Minister Shinzo Abe in 2017. Under the 'Make in India' policy, Japan agreed to provide the technological-cum-financial support at minimal interest rates for developing this project. As per the agreement, 81 per cent of the project cost (estimated at Rs.1,08,000 crore) will be funded by the Japanese government at a minimal interest rate of 0.1 per cent with a 50-year repayment period, including a 15-year grace period. The responsibility of this mega project rests on the shoulders of National High Speed Rail Corporation Limited (NHSRCL), which will act as the sole agency to work on all related projects in future. Under the National Rail Plan (NRP), the Indian Railways envisages to enhance not only the outreach of High Speed Rail (HSR) system to the public but also increase connectivity to all the cities of importance. To this end, NHSRCL identified seven more HSR corridors, for which the debut project reports are in the preparatory stage. These seven HSR corridors are:

1.	Delhi-Varanasi	:	865 kilometre
2.	Delhi-Ahmedabad	:	886 kilometre
3.	Varanasi-Howrah	:	760 kilometre
4.	Mumbai-Nagpur	:	753 kilometre
5.	Mumbai-Pune-Hyderabad	:	711 kilometre
6.	Chennai-Bengaluru-Mysore	:	435 kilometre
7.	Delhi-Amritsar	:	439 kilometre

one-fourth compared to air travel. In this way, bullet trains provide an alternative for more eco-friendly mode of travel. This, in turn, helps to reduce the country's carbon footprint, which is crucial to achieving Sustainable Development Goals (SDGs). It is hoped that the bullet trains will facilitate the shift of passengers from air and roads in major cities. This shift will particularly impact the environment holistically by reducing carbon emissions, thereby improving air quality in a significant way.

Shinkansen technology will be used in the construction of Indian bullet trains. This technology led to the development of Tokaido Shankensen in Japan, which began operation in 1964. Since its introduction, it had a track record of zero casualties. So far as delay is concerned, it had hardly a delay record of merely 40 seconds. It goes without saying that from the perspective of safety and punctuality, India will find the most trustable and reliable mode of transport in the form of bullet train.

From the point of view of travel facilities and passenger comfort too, bullet trains have no comparison. These trains are not only noiseless, pressure controlled and vibration-free but are also more spacious, providing exclusive luggage space. Besides having modern toilets, there is full facility for Wi-Fi as well. Digital display consoles, audio announcement system and on-board assistance make it more useful for elders and specially-abled persons. An additional benefit of bullet trains is that they are safe against natural disasters. For instance, in case of earthquakes, its power failure detection braking system stops it within 80 seconds even if it is running over a speed of 300 kilometre per hour. In bullet trains, a network of sensors continuously monitors the track temperature, rains and crosswinds by sending an alarm signal to an operational control centre.

Unlike conventional trains, bullet

The first Japanese bullet train Tokaido Shinkansen, which started operation on 1 October 1964

Gatimaan Express, which can attain the highest speed of 160 kilometre per hour (Courtesy: Wikipedia)

Vande Bharat Express, which can attain the highest speed of 180 kilometre per hour (Courtesy: Wikipedia)

trains will not have any droppage on the tracks along the way. The sewage and waste generated in the train in toilets or elsewhere in the train will be sorted in large waste retention tanks to be disposed of later on. This makes the train more hygienic and environment friendly.

All the bullet train stations are constructed on the nuances of green-building concept. The building materials used in the design and construction of station buildings are green-pro products. As ecologically sensitive measures, water-efficient fixtures for water conservation and energy-efficient light fittings for power conservation are used in these stations. All station buildings have solar panels on their roof tops for generation of electricity from solar energy. Rainwater harvesting facility and water rejuvenation pits are also a special feature of these stations.

Certainly, bullet trains with such unique characteristics will offer a great excitement for the people of the country. No wonder then that the people will be eagerly waiting for the bullet trains to start operation. There is no gainsaying the fact that the advent of bullet trains in India will usher in a new epoch and give wings to the progress in rail transportation in the country.

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Recent Developments in Biotechnology may bring the Next Agricultural Revolution

Angshuman Kar

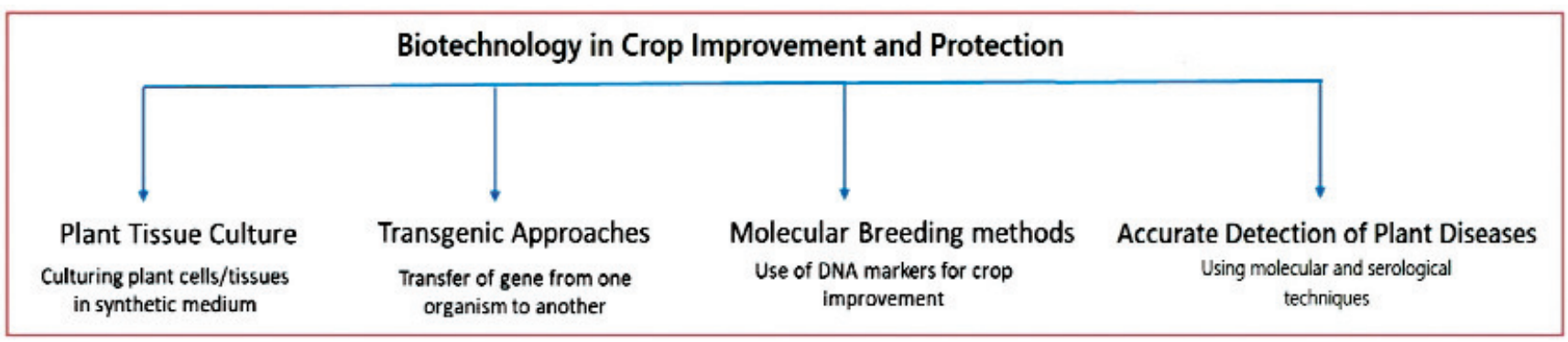
Agriculture has come a long way, from simply harvesting wild strains of cereals and domesticating them to commercial cultivation of genetically modified plants. One of the most significant events in the development of modern agriculture was the green revolution (1940s-1960s), during which the overall yield of crops was drastically increased by the introduction of high-yielding varieties and the application of chemical fertilisers and pesticides. After the green revolution, it seemed that food production could keep pace with worldwide population growth.

But now the ever-rising human population is facing the same threat of food crisis again. Due to extensive use of chemical fertiliser and high-yielding varieties, we have created new problems for ourselves and the environment-loss of soil fertility, erosion of soil, soil toxicity, diminishing water resources, pollution of underground water, salinity of underground water, increased incidence of human and livestock diseases and global warming, extinction of indigenous varieties of crops, are some of them. Therefore, we have to find new and sustainable ways of enhancing food production for the growing population, while also taking into account the current climate change situation and environmental issues our world is experiencing. The green revolution during the 1940s relied mainly on plant breeding and crossing to develop high-yielding varieties. However, using only the conventional breeding techniques will not be sufficient to maintain the food supply at the current population growth rate. In the last few decades plant biotechnology and genetic engineering have acted as a very useful tool to supplement the drawbacks of conventional plant breeding. In both traditional and genetically engineered plant types, biotechnology tools assist in the production of better varieties. Not only that, the use of biotechnological tools has helpedinthe detection and diagnosis of plant diseases, thus assisting in crop protection.

Biotechnological approaches in agriculture

Agricultural biotechnology refers to the use of biological organisms or a range of tools for the improvement of plants, animals, microorganisms, or food derived from them. The application of biotechnology in agriculture has benefitted farmers, producers, and consumers. Following are some biotechnology tools used in agriculture:

- **Plant tissue culture:** Plant tissue culture, in its broadest sense, refers to the in vitro growing of live plant cells, tissues, or organs (seeds,



Approaches of biotechnology in agriculture

embryos, single cells, protoplasts) on a nutritional medium in an aseptic environment. Plant tissue culture techniques include micropropagation, somatic embryogenesis, somaclonal variation, meristem culture, anther culture, embryo culture, protoplast culture, cryopreservation, and secondary metabolite generation.

- **Transgenic approaches/genetic engineering:** Biotechnology is widely employed in the production of genetically modified (GM) crops, in which one or more genes coding for desired features have been added through the genetic engineering process (GE). The genes used to create the transgenic variant might come from the same species or species and organisms unrelated to the recipient organism. Transgenic technology is the method of transferring genes from related or unrelated species to desired agricultural plant species for genetic study and direct DNA modification. This gene technology is also known as recombinant DNA technology or genetic engineering. Mainly there are two techniques for introducing foreign genes into plants. The first technique employs agrobacterium tumefaciens, a soil-borne, gram-negative bacterium that causes crown gall disease in several species. This bacterium possesses a plasmid containing tumor-inducing genes (T-DNA) as well as other genes that aid in T-DNA integration into the host genome. This is accomplished by deleting the majority of the T-DNA but retaining the border sequences (24 bp) that integrate a foreign gene into the genome of cultivated plant cells. The second approach is a 'gene gun', which bombards plant cells with gold particles containing foreign DNA. Some of these particles get past the plant cell wall and into the cell nucleus, where they cause damage to the DNA.

  Over the last 15 years, the combination of recombinant DNA technology with tissue-culture techniques has resulted in the effective transformation and generation of transgenics in a wide range of agricultural plants.

- **Marker assisted selection:** In the case of marker-assisted selection (MAS), the DNA markers are used to guide, support, and streamline plant breeding efforts. Molecular marker-aided genetic analysis aids in gene identification by studying DNA sequences to identify genes, QTL (quantitative trait loci) and molecular markers, and to correlate them with the organism. Molecular marker-aided selection aids in the identification and tracking of previously recognised DNA segments across generations. Molecular marker-assisted breeding uses molecular markers, linkage maps, and genomics to modify and improve plant or animal traits based on genotypic assays.
- **Detection of plant diseases using molecular approaches:** Recent improvements in molecular

biological methods have improved the identification and diagnosis of new, emerging, previously reported, and re-emerging fungal plant diseases. Polymerase chain reaction (PCR)-based tests, isothermal and post-amplification tools, hybridisation methods, and next-generation sequencing (NGS) techniques are well-known for diagnosing phytofungal diseases. These molecular techniques have effectively detected and diagnosed symptomatic and asymptomatic diseases caused by culturable and unculturable fungal pathogens in single and co-infections of significant field, horticultural, floricultural, ornamental, and forest plant species. When the sample load is insufficient to detect, quantitative PCR has been widely employed in the quantification and identification of causal organism.

Recent developments

Let's now discuss some of the most recent innovations supporting the development of agricultural biotechnology.

- In more recent times, *omics technologies* like themetabolomic and transcriptomic-assisted breeding have been applied in MAS. The future of agricultural biotechnology will heavily rely on developing new techniques to

aggregate and evaluate various data kinds in order to optimise the knowledge accessible to breeders.

- **Genomics** is the most powerful approach for interpreting crop species' stress response with adaption features or identifying underlying genes, alleles, or quantitative trait loci.
- Recent breakthroughs in genotyping, sequencing, and phenotyping platforms (phenomics) have turned molecular breeding into *genomics-aided breeding* (GAB). Marker-aided selection (MAS) and genomic selection are the most often employed methodologies for genomics-assisted breeding (GS). SNP arrays, which are very inexpensive and automatically genotyping assays, are being used for high throughput genotyping. It is commonly utilised in crop genetic investigations, including as genome-wide association studies (GWAS), linkage map building, genomic selection, population structure analysis, and gene mapping.
- **Site-directed nucleases (SDN) for targeted gene insertion or replacement:** Agrobacterium tumefaciens-mediated and DNA-coated particle bombardment transformation technologies have a few limitations, such as the possibility for endogenous gene disruption or misexpression of neighbouring genes via trans- or cis-gene regulation. Another disadvantage of using numerous transgenes is that they would likely integrate into various chromosomes and segregate independently, complicating downstream breeding. To overcome these possible flaws, researchers are looking at using SDNs to precisely introduce DNA elements into the plant genome at specified DNA breaks using the plant's DNA homology-guided repair process. Multiple inserted genes can be integrated at a single genomic safe harbour, a designated chromosomal location with minimum positional effects, to optimise transgenic effectiveness without disrupting essential cell activities.
- *RNAi (RNA interference)* is a gene silencing method that uses double-stranded RNA to suppress protein synthesis in target cells. Antisense technology achieves the same outcome using single-stranded RNA. Antisense technology has produced promising results in the development of FlavrSavr, a tomato cultivar with improved shelf-life.
- *CRISPR/Cas9* genome editing technology has shown considerable promise in tackling new agricultural difficulties fast. Recently, Haque et al. showed the potential of CRISPR/Cas9 for improving crop resilience against new pests and abiotic challenges in tropical regions. It is capable of accurately altering the genome sequence of any creature, including plants, to obtain the desired characteristic. Several techniques, such as optimising promoters to drive and express Cas9 and utilising various fluorescence reporters and selection markers, have recently been investigated to enhance plant transformation by CRISPR/Cas9. The CRISPR/Cas gene-editing method may produce heritable, targeted alterations while simultaneously addressing concerns about the presence of foreign DNA sequences by producing transgene-free plants.
- *Loop-mediated amplification (LAMP)*, a modification of PCR, is currently showing success in the detection of fungal diseases and has aided in the identification of Alternaria spp., Colletotrichum spp., Fusarium spp., Verticillium spp., Puccinia spp., Botrytis spp., etc. NGS may be used to find novel and emerging diseases by sequencing fungal genomes on several platforms with no prior knowledge of the pathogen's sequence.

Conclusion

From the green revolution to the gene revolution, agriculture has come a long way. Every day, it evolves at a breakneck pace. With the capacity to understand and manipulate the genetic composition of organisms using biotechnological methods, we can meet the rising demand for food by developing novel crop varieties with higher yield, improved resilience to biotic and abiotic stresses, and environmental sustainability. The application of biotechnology in agriculture has not only increased crop yield but also lowered production costs by reducing the necessity for inputs (pesticides) and improved farmers' lives.

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Department of Scientific and Industrial Research

Ministry of Science & Technology
Govt of India

Biodegradable Flexible Film for Active Food Packaging

The Know-how offers a simple and novel process for production of a composite biodegradable film, which can be utilized for food packaging as an alternative to non-biodegradable plastics.

SALIENT FEATURES

- It is a biodegradable food packaging film
- It is highly flexible
- It possesses high tensile strength
- Prevents mold growth over time

APPLICATIONS

The film is a substitute for the non biodegradable packaging materials

It can beutilized for food packaging as an alternative to non biodegradable plastics

ADVANTAGES

- The composite film is transparent
- The film has antimicrobial properties
- Food can be stored for longer period without any odour buildup and without any transformation of the food colour

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NRDC NRDCIndia1953 National Research Development Corporation www.nrdcindia.com

YInMn Blue: A Long-Lasting Pigment for Blue Colour

Ajai Chawla

The enigma of blue refers to the historical challenge of producing a stable and vibrant blue pigment that would resist fading over time. For centuries, artists and artisans struggled to find a reliable and long-lasting source of blue colour. This challenge was eventually overcome with the discovery of synthetic blue pigments in the 19th and 20th centuries. YInMn is a newly discovered blue pigment that was first reported in 2009 by a team of chemists at Oregon State University. The name YInMn is derived from the chemical elements that make up the pigment: yttrium, indium, and manganese. This pigment is notable for its vivid, stable blue colour and its potential applications in a wide range of fields, including art, architecture and industry. It has been described as the first new blue pigment to be discovered in over two centuries, and its discovery has generated significant excitement in the scientific and artistic communities.

Blue is a colour that holds great cultural significancesince antiquity. Blue symbolises peace and serenity. However, historically it is one of the most recently recognised colours in the English language. Ancient languages such as Greek, Chinese, and Hebrew lacked a word for blue and its mention in Hindu scriptures is also not very clear. Evidence suggests that people may not have even seen the colour without a word to describe it. This pattern holds across cultures, with the colour red being the first colour to be named after black and white. The idea that blue is a fundamental colour that humans see without a word to describe it is questioned by recent experiments showing that people without a word for blue have difficulty distinguishing it from green. It is a colour that is difficult to find in nature, with blue objects such as butterflies and blue eyes being reflections of light rather than natively blue. The captivating Radio lab episode titled Colours, broadcast on public radio stations in the United States, reveals that several ancient languages including Greek, Chinese, Japanese, and Hebrew, lacked a word for the colour blue. This led to speculation that perhaps they were not even able to perceive the colour without a word to describe it.

Interesting facts related to the colour blue

- For much of human history, we didn't have a term for 'blue,' at least not in the way we understand it today.
- Blue was the final colour to receive a distinct name in the English language.
- As blue is uncommon in nature, blue flowers are produced through genetic modification and selective breeding.
- The notion of blue being a colour for boys emerged after World War II when manufacturers sought to increase clothing sales by creating separate clothing lines for boys and girls.
- The pigment Prussian blue is ideal for making copies of drawings. Architects use this hue to reproduce their designs, hence the term 'blueprints'.
- The colour blue is perceived at a wavelength of 450 to 495 nanometers. Since this wavelength is relatively short, light scatters more due to Rayleigh scattering. A colour spectrophotometer evaluates blue by dividing the light beam into component wavelengths and determining the colour's value. This indicates how our perception of the world is influenced by the way we describe it.

One example of this is found in Homer's The Odyssey, where he refers to the wine-dark sea instead of using the words deep blue or green. William Gladstone, a prominent scholar who later served as the Prime Minister of Great Britain, noticed this peculiar use of colour descriptions in the poem. Despite Homer's elaborate descriptions of various objects, including clothing, weapons, animals, and people's features, he often used unexpected colour descriptions, such as referring to iron and sheep as violet and honey as green.Gladstone took it upon himself to count the number of times colours were referenced in ancient books. He discovered that while black was mentioned almost 200 times and whiteabout 100, other colours were infrequent. Red was mentioned less than 15 times, and yellow and green were mentioned less than 10 times.

Upon further examination of ancient Greek texts, Gladstone realised that the word 'blue' was non-existent. It appeared that the ancient Greeks lived in a world that lacked colour and was primarily composed of black, white, and metallic tones. Initially, Gladstone thought this was unique to the Greeks, but Lazarus Geiger, a philologist, discovered that this was a cross-cultural phenomenon. Geiger studied various texts, including Icelandic sagas, the Koran, ancient Chinese stories, and an ancient Hebrew version of the Bible. He found that in Hindu Vedic hymns, descriptions of the heavens were abundant, yet there was no mention of the sky being blue.

The colour we now call blue was not clearly distinguished from shades of green or darker hues in the past. Researcher Geiger discovered an interesting pattern when examining the emergence of the word 'blue' in various languages. It was observed that every language had a term for dark and light or black and white, followed by the emergence of the word for red, the colour of blood and wine, before any other colours. This raises the question of whether the sky is truly blue and what that even means, as explored by Russell in his inquiry.

In a fascinating experiment, the language expert Guy Deutscher raised his daughter without ever describing the colour of the sky to her. When asked what colour she saw when looking up, she was initially unsure and eventually settled on white and later, blue. This suggests that people may not naturally perceive blue without first having a word for it.

Can you truly perceive something if you lack a word for it?

Jules Davido, a researcher, explored this question during an experiment conducted with the Himba tribe in Namibia. The Himba language has no specific term for the colour blue, nor does it distinguish between green and blue. During the Himba experiment, participants were shown a circle consisting of 11 green squares and one blue square. They struggled to identify which square was different from the others, or if they did spot the difference, it took them longer and resulted in more errors than it would for someone who perceives blue as a distinct colour. However, in contrast, as they were familiar with green, when presented with a circle of green squares with only one slightly

Mas Subramanian and YInMn blue

different shade, they could quickly identify the unique square.

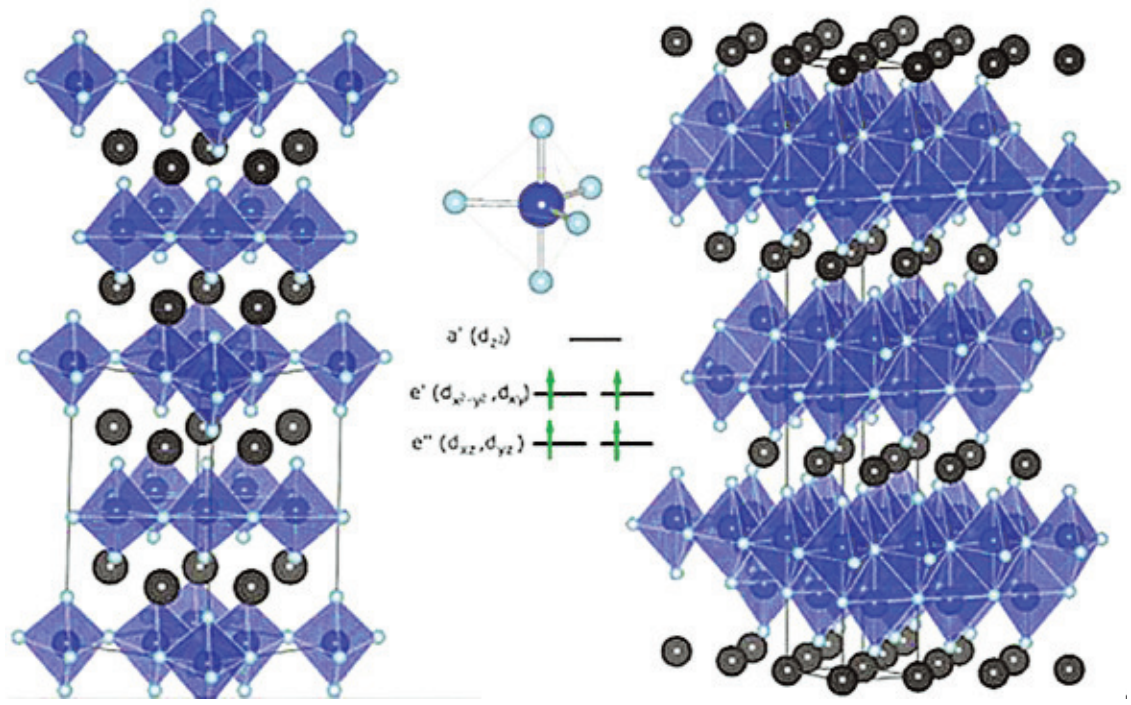
Davido suggests that without a word for a colour, it is difficult for us to recognise its distinctiveness, even though our eyes perceive it in the same way. It implies that even though humans may have seen the colour blue before it became a widely recognised concept, quite possibly they didn't realise what they were seeing. Does colour exist if we see it but don't recognise it? Technically, yes, but our ability to notice it may have developed over time!

Before the advent of chemical science, the finest blue hue was derived from lapis lazuli, a mineral that was ground into a pigment known as ultramarine. Although ancient Egyptians produced a synthetic blue, the first blue pigment created through chemistry, Prussian Blue, was invented in 1706. Cobalt blue was discovered in 1802. Technologists discovered the process to create synthetic ultramarine in 1826, and by the early 20th century, they had also discovered blue organic pigments like phthalocyanine blue. In the period between 1802 and 2009, there were no significant new inorganic blue pigments identified except for manganese blue, which is actually cyan.

And now, a new colour has burst onto the scene - YInMn (pronounced as yinmin) blue, also referred to as Mas Blue, and commercially coded as 10G513 Blue. This stunning shade of blue discovered by Mas Subramanian, has been making waves and for good reason. Not only is it magnificent, but it's also the first new blue pigment to be discovered in over 200 years, captivating scientists, engineers, artists and designers alike with its radiant and unique appearance and applications.

Mas Subramanian is a world-renowned chemist and materials scientist (Milton Harris Chair of Materials Science) who has made ground-breaking discoveries in the field of colour technology. His inspiring journey began in India where he earned a Ph.D. in chemistry from the University of Madras and that led him to pursue his passion for science in the United States. Over the years, he has held prestigious positions at various institutions, including Oregon State University, where he currently serves as a Professor of Chemistry.

In 2009, Subramanian and his team were conducting experiments in their laboratory at Oregon University. During one of these experiments, black manganese oxide was mixed with 'other chemicals' and heated to 1,200 degree celsius. The resulting sample turned a bright blue colour. Coming from an industry research background Subramaniam immediately realised it as a breakthrough in colour technology with potential for wide commercial applications. This colour was named YInMn blue after the elements that comprise it– Yttrium, Indium, and Manganese. Subramanian's discovery



The trigonalbipyramidal structure of YInMn gives rise to its vibrant blue colour

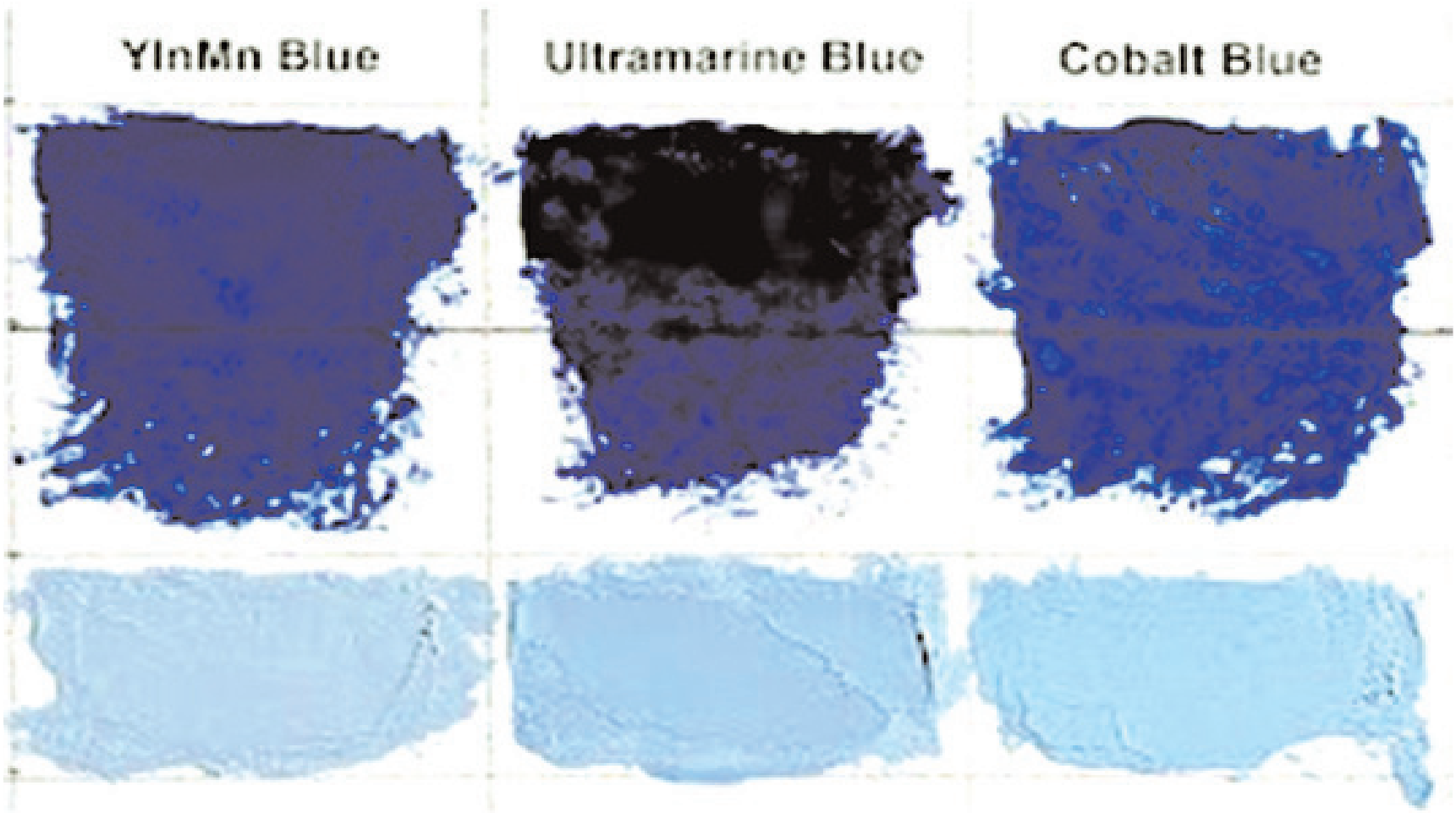
was accidental, but this is not uncommon in the field of science. Many significant scientific discoveries happen unexpectedly when researchers are not actively searching for them. Subramanian quoted Louis Pasteur, who said, "In the fields of observation, chance favours only the prepared mind." Subramanian explained that most pigments are discovered by chance because the colour of a material depends not only on its chemical composition but also on the arrangement of atoms in its crystal structure. As a result, the material needs to be created first, and its crystal structure must be thoroughly studied to understand its colour.

But what makes YInMn blue so special?

YInMn blue is not just a new colour, it's a new era of pigment technology.

At present, it is not possible to produce pigments that can replicate every hue present in the rainbow. Certain colours, particularly blue and indigo, have always posed a challenge to find in nature. Indigo was originally obtained in limited quantities from the Indigoferatinctoria plant in India and was exported at exorbitant price. Although blue dyes are more readily available these days, they tend to lose their intensity quickly. Consequently, what sets this new blue pigment apart?

To find out we need to consult the spectral profile of the pigment, and also the crystal structure of the compound. The pigment's vivid blue



Masstone/Undertone/Tint: You can see how the tint of YInMn Blue is distinctly greyer than the other two

Colour Chart

Out-of-the-tube colours are at the top. Tints of YInMn blue on the left. Other two rows show what happens when you mix YInMn blue with Yellow Ochre and Burnt Sienna + tints of same mixtures

hue arises from its exceptional ability to reflect blue light exclusively while absorbing green and other wavelengths. This striking colouration can be attributed to the molecular arrangement of its atoms, which adopt a trigonalbipyramidal coordination geometry resembling two triangular-based pyramids fused at their bases. YInMn blue's chemical formula is $YIn1\text{-}xMnxO_3$, which has a crystal structure that houses the chromophore (Mn^{3+}) responsible for its vivid blue hue in the trigonalbipyramidal site as indicated by Oregon State's chemistry department.

The unique structure of YInMn blue enables manganese ions to selectively absorb red and green light, reflecting only blue. In a study on the compound, researcher Subramanian noted that YInMn's synthesis at high temperatures signalled its exceptional stability, a property that had long been sought in blue pigments. YInMn has a luminosity that extends beyond the visible spectrum, reflecting approximately 40 per cent of long-wavelength infrared light. Although this type of light is not within the range of colours visible to the human eye, it still produces a warming effect. The pigment is very durable, even when mixed with oil and water, is resistant to acids, and does not fade over time making it an exciting new option for artists seeking a reliable and long-lasting blue pigment.

In addition to its potential use as a pigment, Subramanian believes that YInMn's infrared reflectivity could revolutionise roofing by keeping buildings cooler. He continues to explore YInMn's properties and hopes to discover new pigments by creating intentional laboratory accidents. According to Subramanian, the pigment industry has long struggled

with safety, toxicity, and durability issues, and in this respect YInMn could be a game changer in terms of commercial applications.

In May 2012, the U.S. Patent Office granted the Subramanian team a patent (US82822728) for their new pigment. With its numerous practical benefits and striking beauty, it's no surprise that YInMn blue is fast gaining popularity in the commercial world. Unlike other commercially available chemically-made pigments, YInMn is not prone to fading, is cooler, more durable than cobalt blue due to its ability to reflect heat and absorb UV radiation. It stands out from other pigments currently available, with its vibrant and vivid colour, having potential in various fields such as art, design, fashion, and even architecture and medicine. YInMn's unique ability to reflect infrared light makes it a highly sought-after pigment for energy-efficient coatings, while its durability and resistance to heat and weathering make it a practical choice for numerous products ranging from crayons to roofing materials. Apart from its aesthetic appeal, YInMn blue is also environmentally friendly, being non-toxic and a preferable alternative to other harmful pigments.

As a result, companies are vying to incorporate it into their products. By applying this pigment as a paint to roofs, it could keep homes cooler, and save energy.

One of the notable characteristics of YInMn blue is its weak tinting strength. The striking hue of YInMn blue reflects blue wavelengths and absorbs red and green wavelengths, resulting in a colour that is a blend of cobalt and ultramarine blue. As such it tends to blend in more easily with other colours, which can be surprising to those used to stronger tinting blues. However, this feature is beneficial for those who tend to add too much colour to a mixture, as it helps to prevent the problem of over-saturation. YInMn blue's high opacity, in contrast to ultramarine's transparency, allows for a good coating with a minimal application, making it an ideal pigment for painting. It can help reduce surface temperatures, cooling costs, and energy consumption.

Mas Subramanian's contributions to the field of colour technology are remarkable and have the potential to impact various industries positively. The discovery of a remarkable heat reflecting blue pigment, capable of absorbing UV rays while maintaining thermal stability was just the beginning of Subramanian and his team's exploration. Since the initial discovery, Subramanian and his team of scientists have expanded their research to produce a range of new pigments to encompass a wide spectrum of hues, from vibrant oranges to shades of purple, turquoise, and green. However, they're still searching for a stable, heat-reflecting, and brilliant red pigment, which they believe is the most elusive colour to synthesize.

Subramanian clarifies that they have produced different hues by replacing manganese with iron to achieve orange, manganese with copper to obtain green, and indium with titanium and zinc to create purple. Although these breakthroughs are notable, the pursuit of an ideal red pigment remains the ultimate goal of the colour industry. Currently, the focus is on discovering a red pigment that is both non-toxic and stable.

The inorganic red pigments currently used are insufficient. Subramanian's team is currently developing a red oxide pigment similar to the highly acclaimed YInMn blue, which possesses specific energy gaps between its carbon atoms. If successfully created, this new red pigment could potentially be utilised in the energy industry and be less harmful to the environment. It is possible that soon we may witness the emergence of a new cadmium or vermilion red pigment that could significantly enhance the efficiency of heating systems in homes.

In the past, civilisations worldwide have struggled to find inorganic compounds suitable for producing blue pigments. The new YInMn blue overcomes these limitations with its exceptional stability and durability. It retains its colour even in challenging environments, such as high temperatures, water, and mildly acidic or alkaline conditions. Subramanian commented on the significance of this achievement, stating that "what is amazing" is the pigment's ability to overcome the environmental and durability issues faced by its predecessors. YInMn blue has been likened to a combination of Ultramarine blue and Cobalt blue, filling a gap in the range of colours.

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India International Science Festival (IISF-2023)

A Conglomeration of Science and Society

Dr. Biju Dharmapalan

Science festivals are an occasion when the scientific community and society come together and celebrate the achievements of science and technology. It is an occasion to showcase our scientific strengths and innovations and popularise them among the community. In a geographically and culturally diverse country like Bharat, channelling it through a single platform has always been challenging. The India International Science Festival (IISF), conceptualised by the Vijnana Bharati and supported by various central government agencies, started in 2015 and has emerged as a popular model of science popularisation. The 9th edition of IISF was held on the campus of DBT's THSTI-RCB in Faridabad, Haryana, from 17 to 20 January 2024. The Department of Science and Technology (DST), Government of India and its autonomous institute, the National Innovation Foundation-India coordinated the festival in association with the Department of Biotechnology, Ministry of Earth Sciences, CSIR, ISRO, Department of Health Research, Ministry of AYUSH, Ministry of Health and Family Welfare, Ministry of Information and Broadcasting, Defence Research and Development Organisation, Indian Council of Agricultural Research, the Office of the Principal Scientific Adviser, Vijnana Bharti and the Government of Haryana.

DST Secretary, Prof. Abhay Karandikar welcomed all the national and international guests coming from 23 countries to the India International Science Festival (IISF) 2023. He said that the festival has become the beacon for scientific achievements from all over the country. He also explained the importance of IISF 2023 and briefly introduced the events scheduled spanning 17-20 January 2024 to the audience. He also added that our young students and researchers get inspired and motivated by the scientific progress our country has made and contribute to making India the global leader.

Prof. Ajay Kumar Sood, PSA to the Government of India; Dr. M. Ravichandran, Secretary, MoES; Dr. N. Kalaiselvi, Secretary, DSIR & DG, CSIR; Dr. Rajesh S. Gokhale, Secretary, DBT; Ms. A. Dhanalakshami, Joint Secretary, DST; Shri Shivkumar Sharma, National Organising Secretary, Vijnana Bharati (VIBHA) also spoke on the occasion. Dr. Arvind C. Ranade, Director,

Students Science Village

The Students Science Village event aimed to give children the chance to investigate and interact with science excitingly and interactively. Eminent scientists like Professor Narinder Mehra, Vice President of the Indian National Science Academy (INSA) interacted with students. Prof. Mehra shed light on organ transplantation, providing valuable insights into life-saving medical procedures. The day also featured activities like Foldscope making, hands-on experiments in physics, chemistry, and biology, Inspire Manak Expo and Mega Science Expo, creating a dynamic learning environment for students.

Face-to-Face with New Frontiers of Science & Technology

The 'Face-to-Face with New Frontiers of Science and Technology' event facilitated direct engagement between students/researchers and distinguished figures who excel in different science and technology sectors, spanning academia, research, and industry. The primary goal was to motivate the youth to spearhead India's advancements in science and technology, thereby establishing the nation as a frontrunner in these fields.

An interactive session with students was organised at Face To Face With New Frontiers Of Science & Technology. International experiences were shared by H.E. Madam Ruziah Binti Shafei, Deputy Secretary General, Ministry of Science, Technology and Innovation (MOSTI), Government of Malaysia on 'Malaysia's S&T Development: Pioneering Advancements and Global Opportunities'; and on 'One Health Approach: An Integrated Approach on Sustainable Ecosystems' by Dr. Omosa Ochwang'i, University of Nairobi, Kenya.

National Innovation Foundation (NIF) India and Chief Coordinator, IISF-2023 proposed the vote of thanks.

During the inaugural session, the IISF Programme Guide and IISF News Bulletins in seven Regional Languages–Malayalam, Bangla, Haryanvi, Bhojpuri, Hindi, Marathi and Urdu– prepared by the Science Media Communication Cell (SMCC) of CSIR-National Institute of Science Communication & Policy Research (NIScPR) were released by the dignitaries. The four-day mega science festival was conducted under the following major events that fulfilled the aspirations of every member of society, from students to laymen.

Shri S. Somanath interacting with students of the Space Hackathon event

Science through Games and Toys

The Games and Toys event offered a diverse range of sessions, including innovative teaching methods, workshops on effective teaching using mathematics and science-based sports toys, and activities like 'Fun with Flying Things' based on aerodynamics.

Students Innovations Festival : Space Hackathon

The event brought together young individuals, researchers, and enthusiasts passionate about space technology and exploration. Its goal was to stimulate critical thinking and foster innovative solutions for practical challenges within the realm of space exploration. ISRO-Chairman Shri S. Somanath addressed youth at 'IISF-2023 Students Innovation Festival-Space Hackathon' event. Engaging with students nationwide, he imparted valuable insights and inspiration, motivating participants to delve into the myriad possibilities within space technology. Expanding on his perspective, Shri S. Somanath emphasised the crucial role of space technology across diverse sectors such as agriculture, remote sensing, navigation, transportation, water resources, infrastructure, and many more. He underscored the significance of the Bhuvan portal and its applications for the general public in fostering innovation and contributing to social development.

Vigyanika–ScienceLiterature Festival

Vigyanika stood out as a distinctive component of the India International Science Festival (IISF), focussing on diverse and creative methods of scientific communication organised on 18 and 19 January. The main goal of this event was to highlight India's notable advancements in science and technology (S&T) while establishing a comprehensive strategy for effectively communicating these scientific achievements. Shri A Jayakumar, Vijnana Bharati, discussed the great literary tradition of India, and he recognised the contribution of events such as Vigyanikain the dissemination of science among the general public and to the coming together of contemporary science and literature, which have long been interwoven in Indian knowledge systems. Vigyanika event featured a panel discussion on science communication in regional languages, creative science communication through films, podcasts and social media, and a special session 'Science Communication for Vasudhaiva Kutumbakam'. Paper presentation by researchers and a workshop on Popular Science Writing (PSW) was also conducted as part of Vigyanika. Vigyan Kavi Sammelan and a play on Richard Feyman in Kannada were also organised. Internationally acclaimed author Mr. Marc Prensky and Dr. Sharmila Binti Md. Salleh, Chief Executive Officer at Yayasan Inovasi Malaysia (YIM) graced the valedictory session.

State S&T Ministers, Centre, States S&T Secretaries and Officials Conclave

Government officials, Secretaries, and Ministers of Science and Technology from various states in India attended the session. The purpose of this conclave is to provide a forum for an in-depth discussion on the policies, initiatives, and limitations that are present in the field of science and technology on both the regional and global levels. Many programmes have been launched to make India a leader and destination for futuristic technologies.

IISF Challenge

IISF Challenge (erstwhile Gunnies World Records) continues to inspire young minds and reach new heights through its established tradition. This year around 5,000 picosatellites were made by school students at the IISF Challenge event, creating a new history.

Education for Aspiring India– National Science Teachers Workshop

In the National Science Teachers Workshop, teachers experimented with science and developed innovative teaching strategies on various topics.The topics covered included prism dispersion, electrolysis, enzyme activity demonstration, and the role of carbon dioxide in photosynthesis. A panel discussion titled 'Indian Knowledge System: Ancient to Aspiring India' chaired by Dr. Venkatnarayan Ramanathan was organised as part of the workshop. It emphasised the importance of sustainable science in the contemporary world and advocated for a reduction in consumerism. A plenary talk on the 'Role of Government Institutions: Strengthening Science Education through Schemes' chaired by Dr. Abhay Jere, Vice Chairman of the All India Council for Technical Education was also organised. Dr. Namita Gupta, Head of the INSPIRE Programme at DST, discussed the work undertaken to unravel the mysteries behind various results embedded in ancient teachings.

Young Scientists' Conference

The Young Scientists' Conference strives to offer a platform for the progression of enthusiastic researchers in cutting-edge sciences. This gathering brings together young postgraduates, research scholars, postdocs, academicians, scientists, entrepreneurs, and innovators under the age of 45 from research and development laboratories, academic institutions, and industries. The objective is to facilitate the sharing of experiences, exchange of ideas, and exploration of the research vision of the country.

New Age Technology Show

In the New Age Technology Show, Dr. Akhilesh Gupta, Secretary, Senior Advisor, DST moderated a panel discussion on quantum technologies. Dr. Sudhir Ranjan Jain, Adjunct Professor, UM-DAE Centre for Excellence in Basic Sciences, Mumbai; Prof. Urbasi Sinha, Raman Research Institute, Bangalore;

Dr. Arvind C. Ranade, Coordinator IISF-2023 addressing the National Science Teachers Workshop

Mr. Manish Modani, Principal Solution Architect, NVIDIA, Bangalore and Dr. A. Robert J. Ravi, DDG, DoT, GoI (TBC) participated as panelists. In another session, an interactive talk on Cyber Security was also organised. In the valedictory session of the event, Prof. Abhay Karandikar, Secretary DST announced that the pre proposal has been invited from academia, institutions/ R&D Labs to submit innovative pre-proposals in consortia mode aligned with objectives of National Quantum Mission (NQM) to setup T-Hubs in Quantum Computing, Quantum Communication, Quantum Sensing & Metrology and Quantum Materials & Devices.

National Social Organisations and Institute Meet

The theme of NSOIM-2023 was 'Technological Innovations for Grassroots Development'. It exhibited India's best bottom-up science,

changing rural areas. To highlight impactful grassroots innovations, NSOIM conferred honours to 15 exceptional development models that have significantly uplifted and empowered local communities. The awards aim to acknowledge creative bottom-up approaches and technologies that have enabled access, livelihoods, amenities or environmental rejuvenation at the village level.

Science, Technology and Innovations Exhibition

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The exhibition, which featured technologies from various Indian research and development institutions, attracted the public, especially the students. The exhibits of ISRO attracted people in large numbers. Their exhibit showcased India's space achievements with a focus on the Chandrayaan-3 and Aditya-L1 missions; and XPoSat, a newly launched satellite that will conduct an X-ray polarimetry study on celestial objects attracted people in large numbers. More than 100 stalls were installed at the expo, where 20 were from private organisations, while more than 80 were from government organisations. Among the many displays, a Ram Mandir model was the centre of attraction of the exhibition.

S&T Media and Communicators' Conclave

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The S&T Media and Communicators' Conclave organised on 18 and 19 January highlighted 'the need for science dissemination and media in the *Amrit Kaal*'.

Dr. Manish Mohan Gore, Coordinator, S&T Media and Communicators' Conclave and Scientist, CSIR-NIScPR, welcomed the students, participants, and journalists with a brief address on the need and history of the conclave. Shri Kuldeep Dhatwalia, Senior Consultant, Science Media Communication Cell (SMCC), CSIR-NIScPR, briefed the audience about the theme of the conclave. The chief guest at the inaugural ceremony, Shri Praveen Ramdas, National Joint Organising Secretary, Vijnana Bharati informed the audience on how the narrative is changing regarding science and scientists in the country and how there is a feeling of pride and respect for Indian scientists and researchers worldwide. He stressed the need to communicate science in different regional languages to spread across different parts of the country. The Keynote Address was delivered by Dr. William Selvamurthy, President, Amity STI Foundation. Shri Debobrat Ghosh, Editor, *Science India*, also shared his thoughts during inaugural session. An activity on the theme 'Science & Social Media: Good Practices', and panel discussions on 'Significance of Media in India's Science Diplomacy' and 'Science through Cinema' were organised as part of S&T Media and Communicators' Conclave.

Dr. N. Kalaiselvi, secretary DSIR & DG CSIR, India visiting CSIR-NBRI stall

Start-up, Technology and Innovation B2B Meet

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As part of Start-up, Technology, and Innovation B2B Meet of IISF-2023, an interactive knowledge workshop for the upcoming and budding entrepreneurs was organised. The workshops were centred around start-up canvas, identifying problems, value proposition and differentiation, building on go-to-market strategy, and fundraising. Various national and international delegates from incubators, business strategists and MNCs/ universities participated and presented their experiences and learnings.

Women Scientists and Entrepreneurs Conclave

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The Women's Conclave served as an all-encompassing and empowering forum crafted to support and empower emerging women leaders in the fields of science, entrepreneurship,

Winners of the Students Innovation Festival Space Hackathon

sustainability, and technology. The Women Scientists Conclave at IISF-2023 brought together women leaders in S&T from premier departments and institutions and leading entrepreneurs. It was a demonstration of how women are rapidly overcoming their challenges and contributing to transforming science. Dr. N. Kalaiselvi, Director General CSIR, Ms. A. Dhanalakshmi, Joint Secretary, Department of Science & Technology, along with several senior women scientists, participated in the discussions and gave important suggestions. The Women Scientists and Entrepreneurs Conclave featured insightful sessions on breaking barriers in STEM, modern lifestyles rooted in ancient wisdom, and career opportunities and networking. The four-day mega science event IISF-2023 concluded on 20 January 2024. Recognising the importance of science in shaping the future, he expressed his commitment to further integrate science with society through various initiatives of the State S&T Council.

Dr. Abhay Karandikar (Secretary, DST), Shri Shivkumar Sharma (National Organising Secretary, Vijnana Bharati), Dr. Arvind C. Ranade (Chief Coordinator, IISF-2023), Dr. P.S. Goel (Chairman, National Innovation Foundation), Dr. Akhilesh Gupta, Senior Advisor, DST, Dr. Rajesh S. Gokhale, Secretary, DBT, Ms. A. Dhanalakshmi, Joint Secretary, DST, were also present in the closing ceremony of IISF-2023. Dr. Arvind C. Ranade, Chief Coordinator, revealed a record-breaking turnout with more than 13,000 delegates and 25,000 students, making IISF-2023 a huge success. The ceremony also solidified international collaborations through the signing of MoUs. The second meeting of the Indo-French Joint Science & Technology Committee was also held on the sidelines of IISF-2023. During the valedictory session, winners of the 'Students Innovation Festival– Space Hackathon 2023' were announced, achieving remarkable feats in the world record category. Awards were conferred upon exceptional pavilions, acknowledging excellence in conceptualisation, technology, interactivity and special mentions. The 9th edition of the India International Science Festival has taken Indian science not only to the people of this country but also to 21 different countries that made their presence.

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IPR Day 2024

Hand in Hand
Sustainabilty and Creativity

Dr. Sukanya Datta

The word 'Intellectual Property' relates to inventions of the mind. Creativity is the underlying plank on which it rests. Although there is no single definition of, or even a universally accepted definition/understanding of the term 'creativity', the United Nations designated 21 April as World Creativity and Innovation Day. This was done to raise global awareness of the role of creativity and innovation in all aspects of human development.

Interestingly, there are two other days with links to Intellectual Property Rights (IPR). The first of these is World Book and Copyright Day which is celebrated on 23 April.

The second is World Intellectual Property Day which is celebrated three days later on 26 April. The World Intellectual Property Organization (WIPO) introduced this event to "…raise awareness of how patents, copyright, trademarks and designs impact on daily life" and "…to celebrate creativity, and the contribution made by creators and innovators to the development of societies across the globe." The date 26 April was chosen as the date for World Intellectual Property Day because it was on this date that the Convention establishing the World Intellectual Property Organization entered into force in 1970. IPR Day has been celebrated since 2000. Every year WIPO announces a theme for IPR Day. WIPO's theme for IPR Day 2024 is, 'IP and the SDGs: Building our common future with innovation and creativity." It is pertinent to mention here that SDG is short for Sustainable Development Goals. WIPO attests that World IPR Day 2024 is "..an opportunity to explore how intellectual property encourages, and is able to amplify, the crucial innovative and creative solutions that bolster the common future of all mankind." According to WIPO, the theme is also an opportunity to highlight the role that IP rights, such as, copyright, patents, trademarks, industrial designs play in encouraging innovation and creativity.

Copyright, Patents, Trademarks, Industrial designs are part of the legal framework that provides certain rights to the creators. Each of these covers different aspects.

Copyright covers the legal rights that artists have over their literary and creative works such as novels, poems, painting or even, computer programs. These rights are designed to protect the creator of the work against unauthorised use of the work. But are all geared towards prevention of misappropriation and potentially enhancing profit for the IP-rights holder. Patents are valuable business assets that protect the novel-invention(s) by preventing its use by others without due authorisation. Trademarks help to build brands and establish a business-identity in the market.

An industrial design constitutes the ornamental aspect of an article and the owner of a registered industrial design/design patent has the right to prevent third parties from commercially producing, selling or importing articles that are a copy of the registered design. These are all ways and means by which the owners of intellectual property may safeguard their creative rights and prevent others from wrongly exploiting these. By exercising these rights, the owners can secure economic returns.

To understand the importance of this year's theme, we need to know the Sustainable Development Goals (SDGs) and their aims. The SDGs were outlined at the United Nations Conference on Sustainable Development in Rio–de– Janeiro in 2012. These were defined as universal goals, keeping in mind the environmental, political and economic challenges facing the world. The SDGs actually replaced the Millennium Development Goals (MDGs), which were initiated in 2000

(hence the word millennium in the term). The SDGs were designed to turbo charge what the MDGs had achieved. Interestingly, the 17 SDGs are interconnected such that any success in one area, provides a boosts to others too.

In this context, it is pertinent to recall the message of the then WIPO Director General Francis Gurry when he defined the relationship between intellectual property, innovation and the SDGs. He said that intellectual property as a policy, "…exists to create an enabling environment for– and to stimulate investment in– innovation," and to create a framework for sharing and trading new technologies around the world. He also elaborated that the "…economic imperative at the heart of innovation is fundamental to the process of societal transformation that the SDGs aim to achieve."

(Full details: https://sdg.iisd.org/news/wipo-illustrates-how-innovation-intellectual-property-can-support-sdgs/)

Sustainability is the underlying key to the SDGs. When innovators, creators and entrepreneurs join hands under the IPR umbrella, the propelling force so generated, provides an incentive for innovative growth. In turn, this catalyses investment in the innovation and creativity needed to achieve the SDGs.

There is no doubt that to be able to contribute meaningfully towards the SDGs, one has to be aware of IPR Rights. To this end, the WIPO Academy is playing a sterling role. It serves as a nodal centre, "...for IP education, training and skills-building for WIPO member states, in particular developing countries, least-developed countries (LDCs) and countries in transition. The Academy works to help build human capacity in IP, which is essential to innovation and creativity." (https://www.wipo.int/en/web/ipday/2024-sdgs/resources-and-tools).

WIPO is also supporting innovators in accessing, analysing and using patent information by fostering the development of Technology and Innovation Support Centres in developing countries and countries in transition. It is safe to presume that this training, in the long run, will no doubt lead to sustained implementation of IPR rights that protect the innovativeness of the creators by judicious IP management, including licensing, technology transfer, and IP- commercialisation.

Green technology is another tool for sustainable development. It includes innovative, eco-friendly products, processes and services that place minimal pressureon the environment. Under its aegis fall renewable energy, sustainable transportation, waste management and recycling, energy efficiency solutions etc. All these, spell good news for our over-burdened and polluted planet. One example of how IPR and sustainability may be linked, and even accelerated, is the WIPO Green Network. This facilitates commercial relationships and transactions by connecting green technology providers and seekers.

Technology does not always have to be ultra-sophisticated or 'hi-fi'. Very often a wealth of knowledge lies hidden in Traditional Knowledge (TK) and Traditional Cultural Expressions (TCE) held by indigenous communities who have lived for generations in a sustainable manner. There are many concepts and practices that can be successfully emulated and implemented for sustainability. Entrepreneurship based on TK and TCE may well hold the key to reinforcing the implementation of SDGs. The stakeholders of such TK/TCEs may make strategic and effective use of IPRto safeguard their rights, prevent misappropriation, stop exploitation and support their businesses. This will create new job opportunities, generate income and lead to an amelioration of societal conditions; both locally and globally.

Then again, there are diplomats and members of the judiciary who need to navigate the diverse and complicated international laws and trade negotiations. Knowledge of IPR laws is imperative for them so that they can best represent their country's trade interests. They need to be aware of the relevant IP concepts with respect to important/emerging global issues such as artificial intelligence, climate-change, technology transfer negotiations, TK and SDGs.

On the flip side, some have pointed out that while IPR laws do incentivise innovation, it may also be viewed as being somewhat limiting, particularly in pharmaceuticals and agriculture, sector because it grants exclusive rights to proprietors. This is a complex matter. However,it cannot be denied that IPR is a weapon for good in meeting the SDG goals.

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Genomic origin of lumpy skin disease virus found

Sumita Mukherjee

Animal showing severe skin lesions and nodules on the body and appearance of swollen lymph nodes (Courtesy: BMC Genomics)

Agroup of researchers from the Indian Institute of Science Bangalore (IISc) collaborated with a multi-institutional team to understand the evolution and origins of the virus strains that caused the devastating Lumpy Skin Disease (LSD) in cattle in India in May 2022. LSD virus (LSDV), which causes this disease, was first reported in 2019 from India and has since caused several outbreaks. Since then, about 1,00,000 cows have lost their lives. The direct loss includes deaths of cattle and a decrease in milk production; while the indirect losses include movement restriction of cattle across the country. Prof. Utpal Tatu of the Department of Biochemistry, IISc, as part of a multi-institutional team, decided to probe the cause of the outbreak.

LSDV is transmitted by insects like flies and mosquitoes. It causes fever and skin nodules and can be fatal for cattle. LSDV was endemic in most of Africa, the Middle East and Turkey. But since 2015, several outbreaks have been reported in other countries. There have been two major outbreaks of this disease in India, the first in 2019 and a more severe one in 2022, infecting more than two million cows, states an IISc article.

To investigate the current outbreak, the team collected skin nodules, blood and nasal swabs from infected cattle in various states, including Gujarat, Maharashtra, Rajasthan and Karnataka, in collaboration with veterinary institutes. They performed advanced whole-genome sequencing of DNA extracted from 22 samples.

The biggest challenge for the team was the lack of an established LSDV genome sequencing and analysis pipeline. "We had to adapt techniques from COVID-19 research," explains Ankeet Kumar, the co-lead author. He also added that since data was limited, they had to compile all available global LSDV genome sequences to make a robust analysis.

Phylogenetic analysis performed by the team on all whole-genome sequences of LSDV revealed two distinct LSDV variants circulating in India: one with a low number of genetic variations and another with a high number of genetic variations. The sequence with fewer variations was genetically similar to the 2019 Ranchi and 2020 Hyderabad strains that were sequenced previously. The samples with high variations, however, turned out to be similar to LSDV strains from an outbreak in Russia in 2015.

The team also informed that there are no previous reports of such highly varied LSDV strains in India. Viruses that have DNA as the genetic material, like LSDV, are generally more stable than RNA viruses. Finding so many genetic variations was quite surprising and could explain the severity of the disease, they informed.

The team found a total of 1819 genetic variations including deletions and insertions in various genes, single-letter changes in DNA (called Single nucleotide polymorphisms or SNPs), and genetic variations in regions between genes. The team also found a large number of genetic variations in viral genes critical for binding to host cells, evading immune response, and replicating efficiently, which likely enhanced the virus's ability to cause disease. Samples having highly diverse strains had come from cattle that developed more severe symptoms. With the 'One Health approach', multidisciplinary teams including molecular biologists, computational experts and veterinary doctors came together to address issues of national relevance. Prof. Tatu also emphasised how collaboration between veterinary experts and multiple scientific institutions was critical to tracing the

variants across the country. The team learned a lot from the veterinary doctors as they have the field knowledge, and their perception of the disease was very important to the team. The study has been published in the journal *BMC Genomics*. Such insights can pave the way for improved diagnostics, vaccines and interventions to combat emerging infectious diseases that threaten livestock and livelihoods. These findings also contribute to a better understanding of LSDV and help in developing effective control strategies including development of diagnostic tests. Monitoring genetic variations and protein expression patterns is crucial for detecting new outbreaks, tracking the virus's evolution, and guiding the development of targeted interventions. Prof. Tatu's research group has conducted similar studies on COVID-19 during the pandemic and more recently on the rabies virus.

AI model developed to determine the age of foetus

Researchers at the Indian Institute of Technology Madras (IIT Madras) and Translational Health Science and Technology Institute (THSTI), Faridabad, as part of the 'Interdisciplinary Group for Advanced Research on Birth Outcomes - DBT India Initiative' (GARBH-Ini) programme, have developed the first India-specific artificial intelligence (AI) model to determine the age of foetus in a pregnant woman in the second and third trimesters precisely.

Pregnancy dating or determining Gestational Age (GA) is crucial to obstetric care. Accurate GA is necessary for the appropriate care of

(Courtesy: Health Imaging)

pregnant women and for determining precise delivery dates. Garbhini-GA2 is the first late-trimester GA estimation model developed and validated using Indian population data, according to the report published by IIT Madras.

Currently, the age of a foetus is determined using a formula developed for the Western population. They are likely to be erroneous when applied in the later part of pregnancy due to variations in the growth of the foetus in the Indian population. Garbhini-GA2 accurately estimates the age of a foetus for the Indian population, reducing error by almost three times. It can improve the care delivered by obstetricians and neonatologists, thus reducing maternal and infant mortality rates in the country.

Prof. Himanshu Sinha of the Bhupat and Jyoti Mehta School of Biosciences, IIT Madras, and Prof. Shinjini Bhatnagar of THSTI, and other researchers collaborated in this research. The findings were published in the prestigious international peer-reviewed journal *Lancet Regional Health Southeast Asia.*

In the research paper, the authors mentioned that a large proportion of pregnant women in lower and middle-income countries (LMIC) seek their first antenatal care after 14 weeks of gestation. While the last menstrual period (LMP) is still the most prevalent method of determining gestational age, ultrasound-based foetal biometry is considered more accurate in the second and third trimesters.

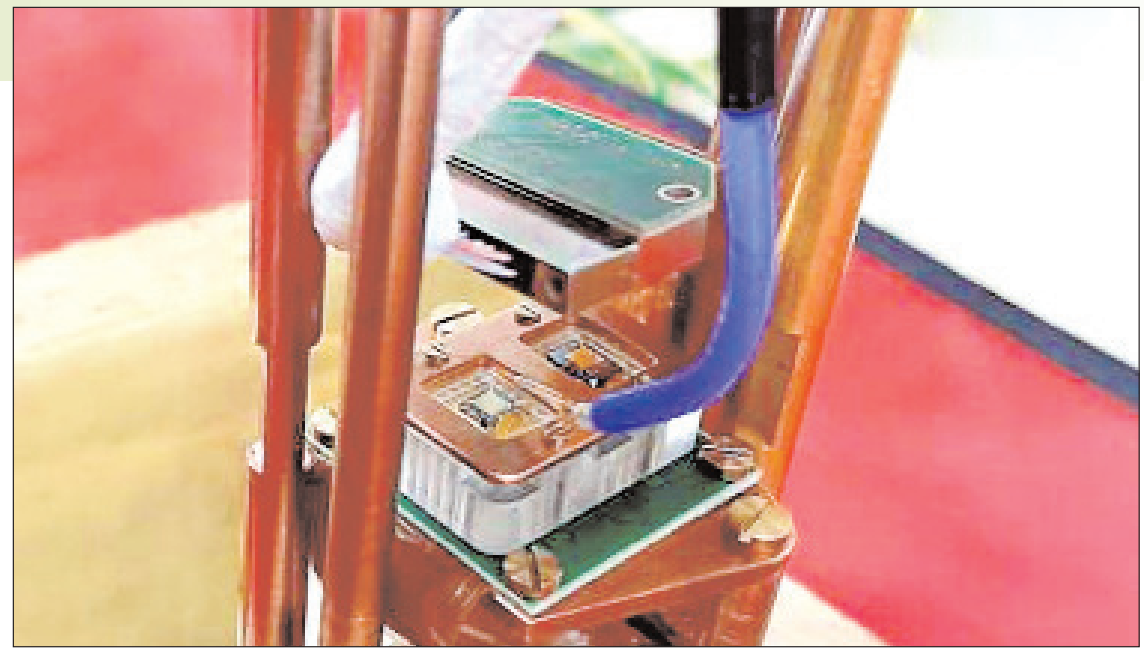
In LMIC settings, the Hadlock formula, originally developed using data from a small Caucasian population, is widely used for estimating GA and foetal weight worldwide as the pre-programmed formula in ultrasound machines. This approach can lead to inaccuracies when estimating GA in a diverse population. Therefore, the team worked on developing a population-specific model for estimating GA in the late trimesters, which was as accurate as the GA estimation in the first trimester. This model outperformed the currently used dating models by reducing GA estimation median errors by more than three times with GA estimates comparable to the GA dating in the

first trimester. Additionally, the Garbhini-GA2 model estimated preterm birth (PTB) rates closer to the rate calculated in the first trimester, while the published formulae overestimated these PTB rates. Garbhini-GA2 model can be adopted for clinical purposes across the Indian subcontinent after a pan-India validation. "From an epidemiological perspective, combining our previously published Garbhini-GA1 model with the newly introduced Garbhini-GA2 dating formula enhances the precision of pregnancy outcome estimates, including preterm birth, small for gestational age (SGA), and stillbirth in the Indian population, where accurate GA is crucial," mentioned the researchers in their study.

Superconductor gets a control function

Superconductors are materials that can conduct electricity without electrical resistance, which make them the ideal base material for electronic components in MRI machines, magnetic levitation trains or particle accelerators. However, conventional superconductors are easily disturbed by magnetism. An international team including researchers from the University of Würzburg (JMU) has successfully created a special state of superconductivity. They have developed a hybrid device consisting of a stable proximitised-superconductor enhanced by magnetism, whose function can be specifically controlled.

They combined the superconductor with a special semiconductor material known as topological insulator.



Sample holder for measurements at millikelvin (-273^{0}C) (Courtesy: Mandal/JMU)

Topological insulators are materials that conduct electricity on their surface but not inside. This is due to their unique topological structure, i.e., the special arrangement of the electrons, explains a researcher from the Institute for Topological Insulators at the JMU. This helps in equipping topological insulators with magnetic atoms so that they can be controlled by a magnet. They did this by observing the dependence of the critical current on the magnetic field and temperature.

The superconductors and topological insulators were coupled to form the so-called Josephson junction, a connection between two superconductors separated by a thin layer of non-superconducting material. This allowed the team to combine the properties of superconductivity and semiconductors. The advantages of a superconductor were combined with the controllability of the topological insulator. They could control the superconducting properties precisely with the use of an external magnetic field. The team calls this to be a breakthrough in quantum physics.

The research team has published a paper in *Nature Physics*, in which they write about how a superconductor, when exposed to a spin-exchange field, can exhibit spatial modulation of its order parameter, commonly referred to as the Fulde-Ferrell-Larkin-Ovchinnikov state (p-FFLO). Such a state can be induced by controlling the spin-splitting field in Josephson junction devices, allowing access to a wide range of the phase diagram. The special combination creates an exotic state, in which superconductivity and magnetism are combined, which are normally opposite phenomena, rarely coexisting.

This new "superconductor with a control function" could be important for practical applications, such as the development of quantum computers. Unlike conventional computers, quantum computers are based not on bits but on quantum bits (qubits), which can assume not just two but several states simultaneously. This turns out to be a much more efficient way of solving complex problems like chemical simulations.

Quantum bits are currently very unstable because they are extremely sensitive to external influences, such as electric or magnetic fields. The present findings could help stabilize quantum bits so that they can be used

in quantum computers in the future, the team explains.

Quantum computing uses specialised technology that includes computer hardware and algorithms taking advantage of quantum mechanics to solve complex problems that classical computers or supercomputers cannot solve or cannot solve quickly enough. It is finding huge applications in developing superfast computers, which in turn will help in solving challenges such as developing next-generation e-vehicles, complex energy requirements, or cosmic material.

Air pollution may be disrupting plant reproduction

A new study has revealed that the chemicals in air pollution may be disrupting plant reproduction, as the pollutants mask the scent of flowering plants and make them more difficult for pollinators to find. The study, published in the journal Science, indicated that chemicals in air pollution such as Nitrate radicals (NO_3) and ozone pollutants, common by-products of car exhaust and burning fossil fuels can degrade the natural chemical scents of flowers, making it harder for pollinators, like moths, to find flowering plants. As pollinators play a big role in community ecology, they are critical for the fitness of plants and in turn for our food system and food security.

Chemical pollutants not only reduce animal survival and reproduction but can also disrupt their senses, changing their behaviour and interactions with other species. When someone smells a rose, the fragrance

comprises a diverse bouquet composed of different types of chemicals, explained the co-lead author of the study, a biology professor at the University of Washington. Each flower has its scent made up of a specific chemical recipe. Common air pollutants such as ozone degrade floral scents, potentially affecting insects' ability to locate and pollinate flowers.

The researchers tested the effects of ozone and NO_3 on nocturnal hawkmoth pollination of a desert plant. They found that the degradation of scent molecules by NO_3 led to a decline in the visitation of hawkmoth in wind tunnel and field experiments. They also observed reductions in fruit set and plant fitness.

The team analysed the scent samples from evening primrose flowers and observed how each natural chemical in the flowers' scents reacted with the pollutants in wind tunnels and field experiments. Wind tunnels provide an experimental environment where certain variables can be constrained or controlled to improve the understanding of wind erosion processes with direct testing. Field wind tunnels are similar to their laboratory counterparts, but will have a portion of the working section that integrates the natural surface into the experiment. The researchers found that the nitrate radicals masked certain chemicals, including mono-terpenes, which are particularly attractive to moths. Nitrate radicals had a bigger impact on the mono-terpenes that moths rely on to find and pollinate flowers.

The researchers found that in the wind tunnel experiments, tobacco hawkmoths were 50 per cent less accurate in locating the flowers, and white-lined sphinx moths were not able to find the flowers at all. In the field experiments, moths had up to 70 per cent decline in the accuracy of finding the flower sources when nitrate radicals were introduced. The team found that NO_3 is significantly reducing a flower's 'reach'–how far its scent can travel and attract a pollinator before it gets broken down and is undetectable. In a separate study, the researchers worked on the potential impacts of air pollution on insect pollination and noted how air pollutants can hinder floral scents as well as visual cues, such as plant petal size and colour. All these researches highlight the urgency of reducing human-caused pollution.

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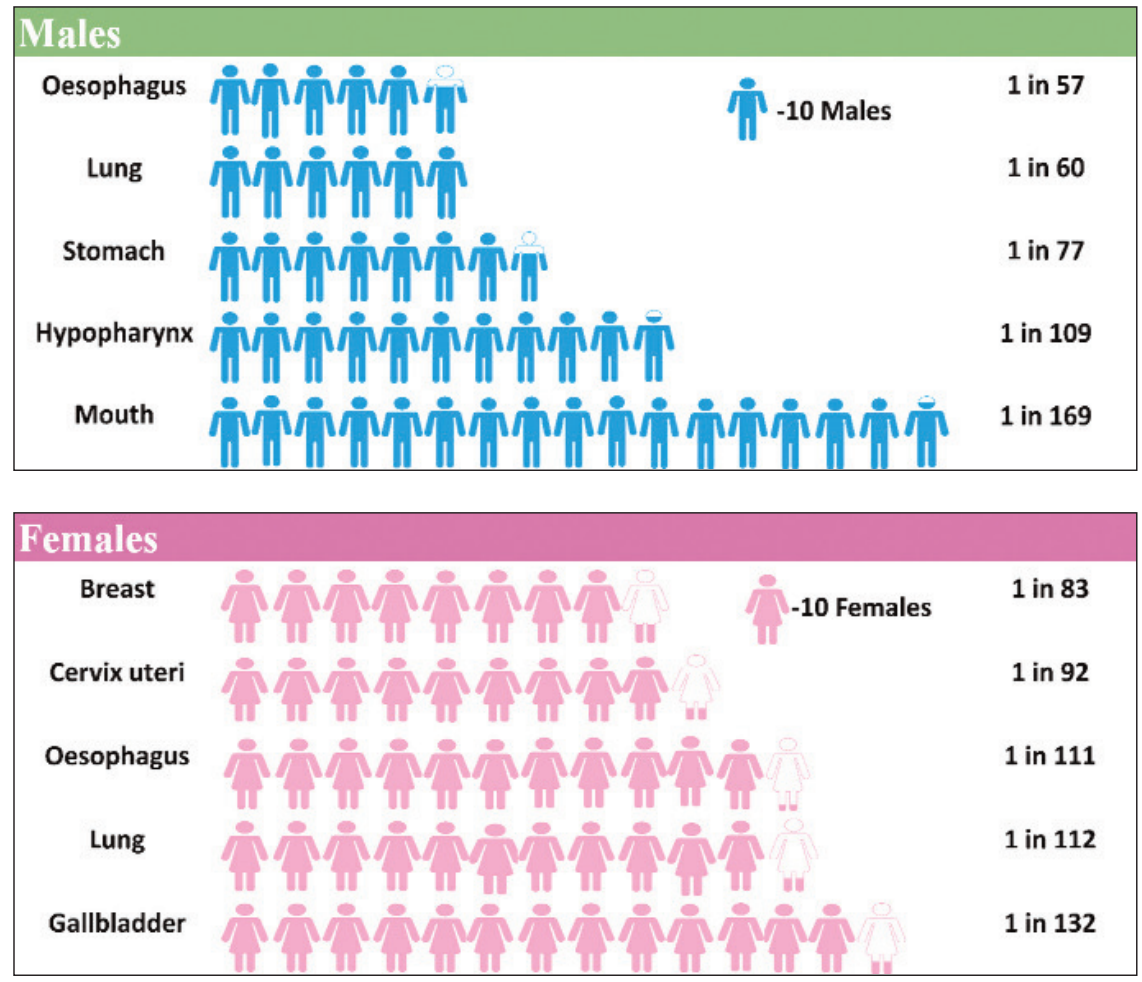
Cancer analysis goes digital



Possibility of one in number of persons developing Cancer in (0-74) years of age - Pooled North East
(Source: https://ncdirindia.org/datavisual/Home1.aspx)

Bengaluru-based National Centre for Disease Informatics and Research (NCDIR), an autonomous institute under Indian Council of Medical Research (ICMR), with an objective to sustain and develop a national research database on cancer and other non-communicable diseases is actively involved in planning, direction, development, coordination, and evaluation of a national program of cancer surveillance. This noble objective is being achieved through a web-based assessment and analysis tool by the name "Cancer Samiksha."

This digital tool is actively involved in cancer analysis in India on the basis of data derived from the National Cancer Registry Program (NCRP).

Before we begin with what is NCRP all about, let us dive in the world of cancer. What is the reason of its spread and prevalence these days? Different medical experts gave their opinions. Some say it is due to the growing life expectancy; the reason being, people with advanced age become immunocompromised, and this leads to disease contraction. By immunocompromised, we mean an individual whose body's ability to fight off infections is low. Some experts emphasised on the adoption of western lifestyle, longer working hours, stressful lives, smoking and alcohol consumption, obesity, and leading a sedentary lifestyle. Environmental factors also play an important role in cancer contribution. This consists of long duration exposures to radiations including sun rays. Lack of awareness related to health promotion and disease prevention, in addition to lack of resources for early diagnosis and prevention in many areas of the country also play a significant role in cancer spread.

With the growing cancer prevalence in the country, it is important that we keep a constant check on its spread in a population. For this, regular assessment and analysis becomes essential for early diagnosis followed by its treatment. As Digital India Campaign is gaining popularity day-by-day, digitisation has entered the healthcare sector as well. The National Cancer Registry Program performs a systematic data collection on identified cancer parameters. It determines the extent of cancer spread, burden, occurrence of new cases, long-term changes in the trend, and determines the clinical parameters of different cancers. The body vitals like blood pressure, pulse rate, heart rate, etc. are studied.

Since December 1981, NCRP started as a long-term activity of ICMR with a countrywide network of cancer registries. It was categorised the population-based and hospital-based registries. Initially, population-based cancer registries (PBCR) began in Bengaluru, Chennai, and Mumbai. While, the hospital-based cancer registries (HBCR) commenced at Chandigarh, Dibrugarh, and Thiruvananthapuram in January 1982.

The source population of PBCR

includes government hospitals, private hospitals, nursing homes, clinics, diagnostic labs, imaging centres, and registrars of births and deaths. These registries from the multiple sources of registration (SoR) collect data on every new case of cancer from a well-defined population.

HBCRs deal with the information recording on cancer patients in a hospital which is irrespective of the residential status of the patient. Sometimes, HBCR collated data fall under PBCR data when lying within the same region. Gradually, the number of population-based and hospital-based cancer registries grew to 38 and 189, respectively, within the NCRP network. The collated data undergo rigorous checks before being published.

The data generated by National Cancer Registry Program provides essential inputs to the National Program for Prevention and Control of Cancer, Diabetes, Cardiovascular Disease and Stroke (NPCDCS), Ministry of Health and Family Welfare (MoHFW), Government of India. Due to growing concerns of rising cancer incidences in the country, it becomes extremely important to keep a strict check on the cancer spread in the country so that on a national level government can take systematic steps for its screening, early detection, and treatment at an early stage. However, there are researches going on worldwide for the treatment of advanced stage cancers also, still it is always better to cure at an early stage itself. With NCRP in the country, it will be easier for all of us to get a clear direction towards effective cancer control. Planning, establishment of treatment facilities, resource allocation, prevention programs, and impact assessment of various activities like screening, and awareness generation regarding cancer will also be easily undertaken by the health professionals. Cancer management will become easy. Hospitals benefit by using the registry data for the improvement of their cancer care services. The data collected in the cancer registry is scrutinised properly, at the time of entry, before analysis, to adhere to the international norms.

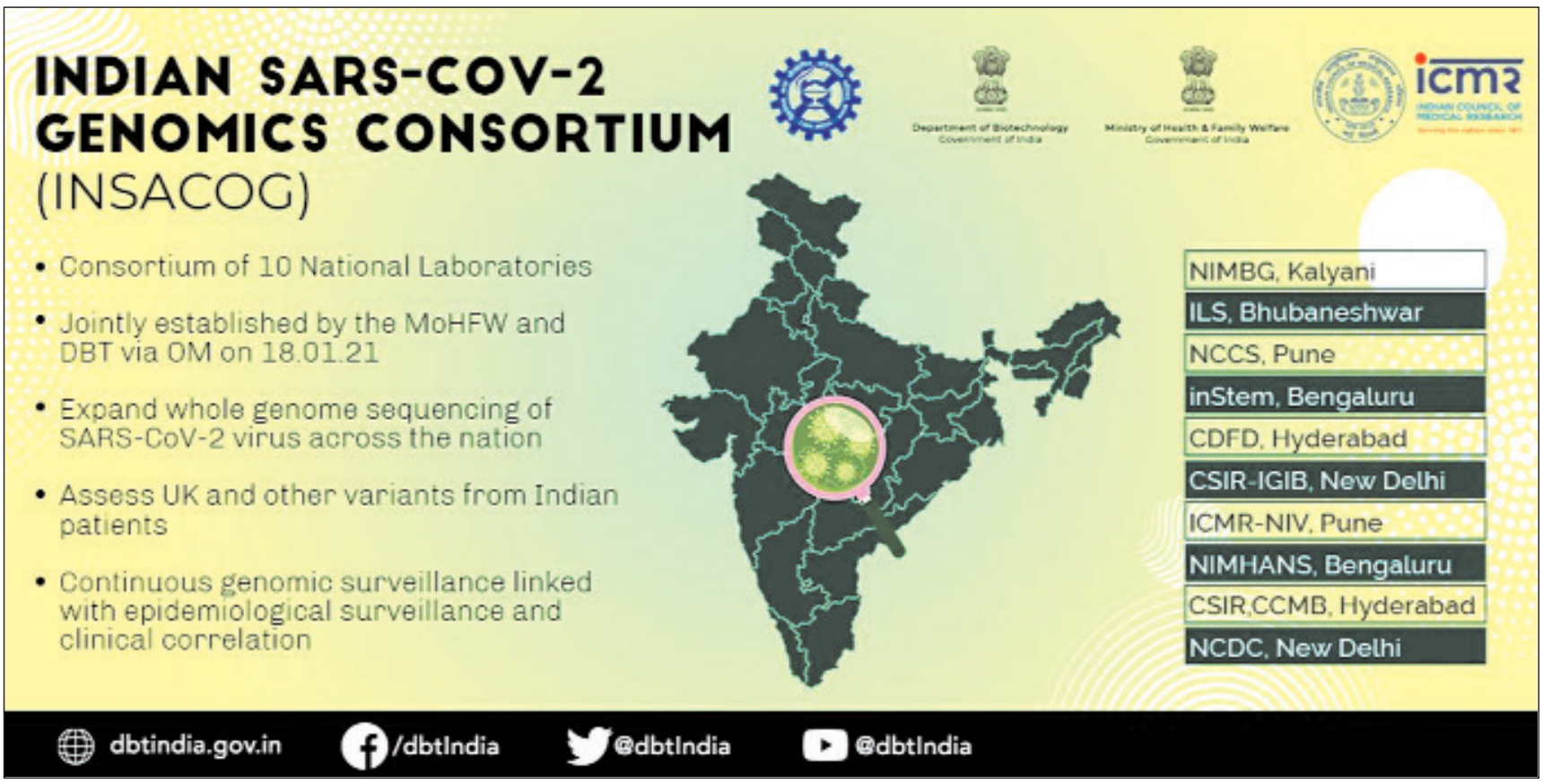
Indian *SARS-CoV-2* Genomic Consortium (INSACOG)

The Indian *SARS-CoV-2* Genomics Consortium (INSACOG), jointly initiated by the Department of Biotechnology (DBT) and Union Ministry of Health with the Council for Scientific & Industrial Research (CSIR) and the Indian Council of Medical Research (ICMR), is a multi-institutional consortium of 67 laboratories to monitor the genomic variations in *SARS-CoV-2*.

Key objectives of INSACOG

The purpose to establish INSACOG was to:

- Help in understanding the spread and evolution of the virus, and to tackle its future spread.
- Genomic study of accumulated



mutations to enable comparison of virus samples and viral lineages in order to understand if local outbreaks are caused by transmission of specific viral variants.

- Analysis of *SARS-CoV-2* genome sequences to assess whether these mutations affect clinical outcomes, disease severity and death.
- Genomics data to be used for informed public health intervention measures; help develop diagnostics and development of therapies and vaccines for specific variants of concern.

The following three components of the Consortium work synergistically towards achieving the above objectives:

A. Sentinel surveillance and surge surveillance mechanisms for early detection of genomic variants and assist in formulating effective public health response for containment.

B. Waste water based epidemiologyto detect variation in viral load in sewage samples to get early indication of increase in infections.

C. Hospital networkstudy to evaluate the correlation of severity of disease with virus variants.

Achievements

- Scaled up genomic surveillance capability– from 10 to 67 sequencing laboratories spread across the entire country, including remote regions, e.g. Ladakh and Northeast.
- Harmonised methods of sampling, processing, sequencing and data analysis.
- Establishment of network of over 400 sentinel laboratories for testing and supply of clinical samples to sequencing laboratories for genomic surveillance.
- Real time reporting of genomic data to National Centre for Disease Control through Integrated Health Information Platform (IHIP), centralised analysis in Indian Biological Data Centre (IBDC) and submission of data in the Global Initiative on Sharing All Influenza Data (GISAID).
- Regular reporting to Government of India through reports and public dissemination of results through bulletins.
- Until date, INSACOG and its networks have generated and shared substantial viral genome sequences during the pandemic– over 3.33 lakh viral genome sequences of *SARS-CoV-2* collected at different time points from various locations in the country.
- INSACOG labs have rapidly sequenced samples from infected international travellers from various airports in India which has led to efficient containment of transmission of variants of concern originating from abroad.
- INSACOG investigations of outbreaks in Maharashtra led to identification of Delta at the beginning of the second wave (B.1.617).
- Immediately, scaled up surveillance led to identification and tracking of the Omicron.
- Deep analysis of sequences with epidemiological data led to important information through prominent peer reviewed scientific publications.
- The Consortium has established a network of fifteen hospitals for genome surveillance of samples collected from patients admitted for medical attention and a wastewater surveillance program at ten urban sites across the country.
- Scientific and technical training of clinicians and laboratory staff have been undertaken by INSACOG labs to disseminate the knowhow of genomic surveillance.

Indian Food Composition Tables (IFCT)

Keeping the food database updated on a regular basis is a challenging task. The National Institute of Nutrition (NIN) under the aegis of Indian Council of Medical Research (ICMR), Hyderabad is one of the oldest research centres in the country known for public health, nutrition, and translational research. The institute is constantly involved in updating the Indian food composition tables since the groundbreaking food nutrient profiling began in the year 1937.

The 'Indian Food Composition Tables-2017' in the form of a book compiled by NIN provides nutritional information on 528 important foods categorised in 20 food groups on the basis of 151 distinct food constituents. Food groups comprise cereals and millets, grain legumes, green leafy vegetables, other vegetables, fruits, roots and tubers, condiments and spices, nuts and oil seeds, sugars, mushrooms, miscellaneous foods,

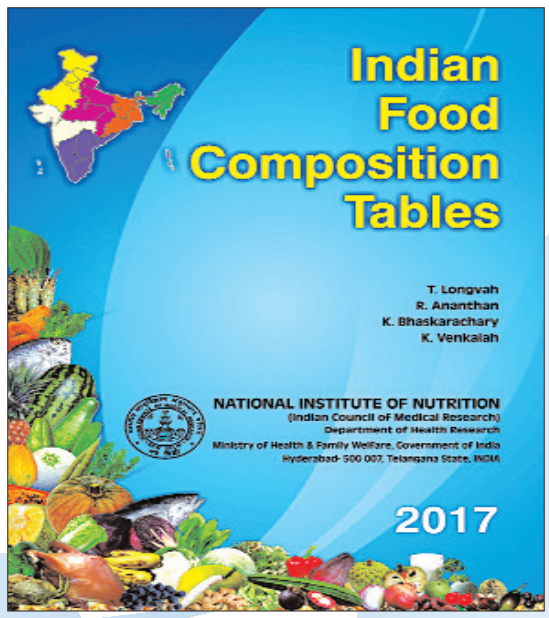
A023. Wheat, vermicelli *(Triticum aestivum)*; A. Sewai; B. Semai; G. Ghaun ni sev; H. Siwain; Kan. Shevige; Kash. Sewian; Kh. Sewai lieh; Mal. Semiya; Mar. Siwain; O. Simai; P. Sevian; Tam. Semiya; Tel. Semiya; U. Semiya.

A024. Wheat, vermicelli, roasted *(Triticum aestivum)*; A. Gom sewai; B. Semai; G. Ghaun ni Shekeli sev; H. Siwain; Kan. Shevige; Kash. Sewian; Kh. Sewai saw; Mal. Semiya; Mar. Siwain; O. Simai; P. Bhooni sevian; Tam. Semiya; Tel. Semiya; U. Semiya.

An excerpt from IFCT book

milk and milk products, egg and egg products, poultry, animal meat, marine fish, marine shellfish, marine mollusks, freshwater fish and shellfish, and edible oils and fats. Except poultry and egg, the database of all food components is for foods in their raw form. The food constituents fall under the following categories: dietary fibre, water soluble vitamins, fat soluble vitamins, carotenoids, mineral and trace elements, starch and individual sugars, fatty acid profile, fatty acid profile of edible fats and oils, organic acids, polyphenols, oligosaccharides, phytosterols, saponins and phytates, amino acid profile, molecules that form proteins responsible for growth and repair of body cells and tissues.

The pictorial description of foods we consume on a daily basis is an interesting value-addition to the database. Each food item is described by its most common name in English language, scientific name, and photo of the food sample. The food is arranged in alphabetical manner. Food names are also listed in regional languages of India - Assamese, Bengali, Gujarati,



Hindi, Kannada, Kashmiri, Konkani, Malayalam, Manipuri, Marathi, Nepali, Oriya, Punjabi, Sanskrit, Telugu and Urdu. In case of animal sourced foods, the specific body part is analysed. Every food analysed has a unique four-character alphanumeric code for identification, which makes tracking easy.

India Today, July 2023 states, "According to a joint report by FAO, IFAD, UNICEF, WFP, and WHO, in comparison to 42.1 per cent of the global population, 74.1 per cent of the Indian population cannot afford healthy food." Thus, food composition databases with collected data on nutritional food content hold importance. The applications of food composition tables include development of dietary guidance for individuals and populations on the whole. Additionally, it plays a key role in policy development, food production, trade and commerce, and research and development. The new Indian Food Composition Table, IFCT-2017 is the major source of food composition data containing extensive information about every possible food consumed till date in India. It is generated, developed, managed, and maintained by the National Institute of Nutrition, ICMR, Hyderabad.

The USP of this table is that all the nutrient values are derived from in-depth analysis. The food samples are collected from six geographical regions of the country - North, South, East, West, North-East, and Central. The consistency and validity of the data set are in line with the FAO/INFOODS food composition data guidelines.

(Science Media Communication Cell, CSIR-NISPAR)

New pancreas-mimicking system ensures responsive insulin delivery

A new silk-based hydrogel system that mimics the pancreas, offers a potential breakthrough in insulin delivery for diabetes treatment. The proposed innovative approach can provide a more efficient and responsive method for insulin release, addressing the challenges faced by individuals with both Type-1 and advanced stage Type-2 diabetes.

Prof. T. Govindaraju and his team from the Bioorganic Chemistry Laboratory, New Chemistry Unit at JNCASR, Bengaluru (an autonomous institution under the Department of Science & Technology) were motivated by the success of a previously developed passive insulin release system. In that study, insulin was encapsulated in the silk protein 'fibroin' and injected under the skin, resulting in the slow diffusion of insulin over a period of five days. Building on these findings, Prof. Govindaraju's team modified the silk protein to create a super smart system that releases insulin in response to glucose levels in the blood.

Explaining the science behind this modification, Prof. Govindaraju says, "The goal was to create a system that mimics the function of the pancreas, an organ responsible for insulin production and release in the body, providing a continuous and controlled supply of insulin in response to elevated glucose levels in the body, to manage diabetes." The findings of this study were published in *ACS Applied Materials and Interfaces on* 17 October 2023.

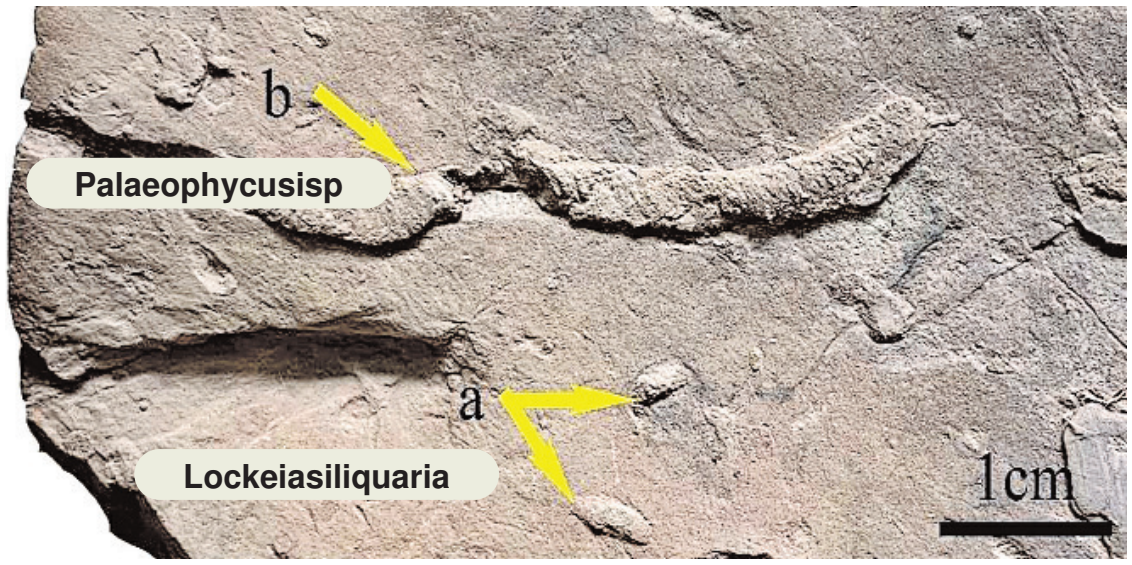
In this study, the researchers added special elements to the system that is responsive to abnormally high glucose levels in the body to trigger the release of insulin, when needed. On injecting the silk formulation, it forms a gel underneath the skin, acting as a small storage area for insulin. Insulin, a hormone playing an important role in controlling blood sugar, is then released in a controlled manner from this storage area, helping maintain the right levels of blood sugar in patients with diabetes. High blood glucose level, indicating a need for insulin, prompts the release of insulin from the gel. This system is similar to having a tiny, self-regulating device that gives us just the right amount of medicine when we need it.

To improve the ability of this gel for insulin release, the team used a glucose-sensing molecule called phenylboronic acid (PBA) and an enzyme called glucose oxidase (GOx). These components work together to sense changes in glucose levels and trigger the release of insulin from the gel. When the gel is injected under the skin, its sponge-like structure helps hold and release insulin as needed, making it a glucose-responsive hydrogel platform for insulin release.

In the long term, this smart system could potentially offer a more natural

and personalised way to deliver insulin, mimicking the insulin-releasing ability of pancreas. Initial tests on mice showed promising results in terms of efficacy and biocompatibility. It effectively controlled insulin delivery and normalised blood sugar levels. The transition to human trials and further development, however, is contingent upon industry partnerships and funding. While the potential applications of this proposed silk-based system are many, ranging from drug delivery, wound healing to tissue engineering for various medical conditions, the team is now working on industrial collaborations to implement the system. The silk-based insulin delivery system indeed has the potential to change lives, offering a more convenient and responsive way to manage diabetes, without the hassle of traditional insulin injections.

Prof. T Govindaraju and his team at JNCASR have developed a pancreas-mimicking insulin delivery system that could hold a lot of promise for diabetes management (Credit: Shutterstock)



Fluvial Ichnofossils identified in Siwalik rocks help assess the environmental conditions in prehistoric times

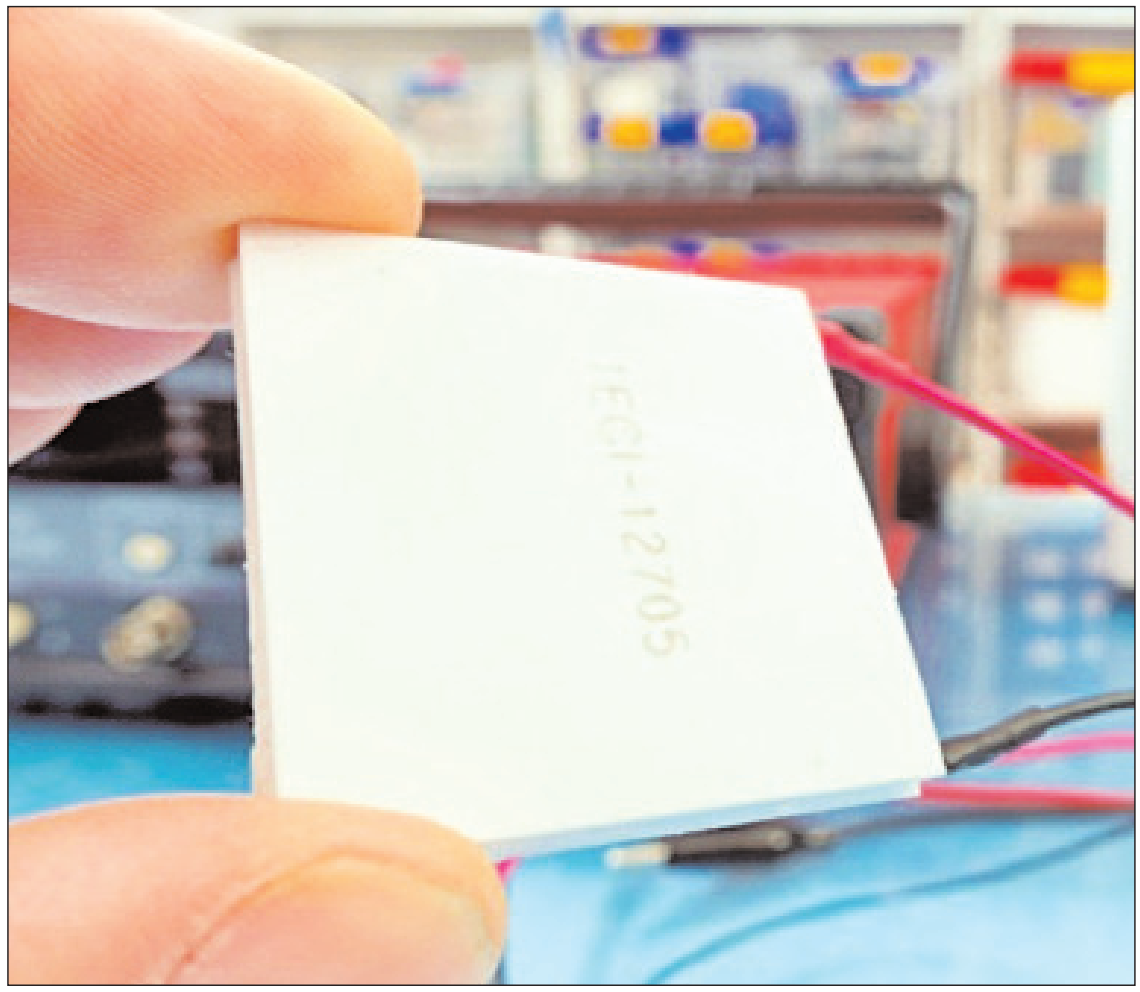
Beaconitescoronus

Trace fossils or Ichnofossils found by researchers from the Siwalik sediments in Pathankot District of Punjab have helped them assess the environmental conditions that prevailed in the region during prehistoric times. The findings indicated that the studied area was having semi-arid, low sedimentation rates, low energy deposits and well oxidising environment approximately 11 million years ago. Ichnofossils are the biogenic sedimentary structures that reflect the diversity and behaviour of organisms and their connection to environmental conditions, such as substrate properties, nutrient availability, and mainly oxygen conditions.

Researchers from the Wadia Institute of Himalayan Geology (WIHG), an autonomous institution of Department of Science and Technology (DST) found ichnofossils, representing an age equivalent to the Late Miocene of Geological Time Scale (approximately 11 million years old) from the Siwalik sediments exposed around the Dunera region of Pathankot District of Punjab.

In their study published in the *journal of Earth System Science,* Ichnofossil assemblages have been discovered from the Miocene

Researchers team



(Credit: Shutterstock)

succession rocks exposed along the Katilu Khad section, Dunera, Punjab.

The team led by Mr. Abhishek Pratap Singh, a Senior Research Fellow along with Dr. Shivani Pandey, Dr. Ramesh Kumar Sehgal and Dr. Ningthoujam Premjit from WIHG have identified eight ichnotaxa with 12 ichnospecies. These include *Arenicolites isp., Beaconitescoronus, Helminthopsistenuis, Lockeiasiliquaria, Palaeophycustubularis, Palaeophycusisp., Planolitesannularis, P. beverleyensis, Skolithoslinearis, Taenidiumbarretti, T. cameronensis, and T. serpentinum,* along with some unidentified burrows.

The fossil composition shows a mixture of Scoyenia and Mermia ichnofacies representing a nonmarine environment. The ichnofacies indicate well-oxygenated, low-energy deposition along with exposure to air- conditions which characterise a fluvial environment. In the recent past, the team also reported some significant fossils of rodents from the same region.

New synthesised material combines metal and glass properties

A newly synthesised material that exhibits the properties of both glass and metal can efficiently convert waste heat to electricity and help improve energy efficiency and sustainability. The scientific community is exploring sustainable and environmentally acceptable energy alternatives in response to the pressing problems presented by the depletion of non-renewable fossil fuels. Thermoelectric (TE) materials present a promising avenue for changing the global energy landscape because of their capacity to transfer waste heat into useful electricity. However, to maximise a material's energy conversion efficiency and achieve high TE performance, careful optimisation of both thermal and electrical transport characteristics is required. In a recent groundbreaking research paper, Prof. Kanishka Biswas

from New Chemistry Unit at Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru (an autonomous institution under the Department of Science & Technology, Government of India) and his research team has presented a material that exhibits metal like electrical conductivity but glass like thermal conductivity which has never been reported earlier. This study, published in *Advanced Materials*, focusses on synthesising a crystalline material named ytterbium (Yb) doped AgSbTe2, demonstrating unique characteristics in heat and electron transport.

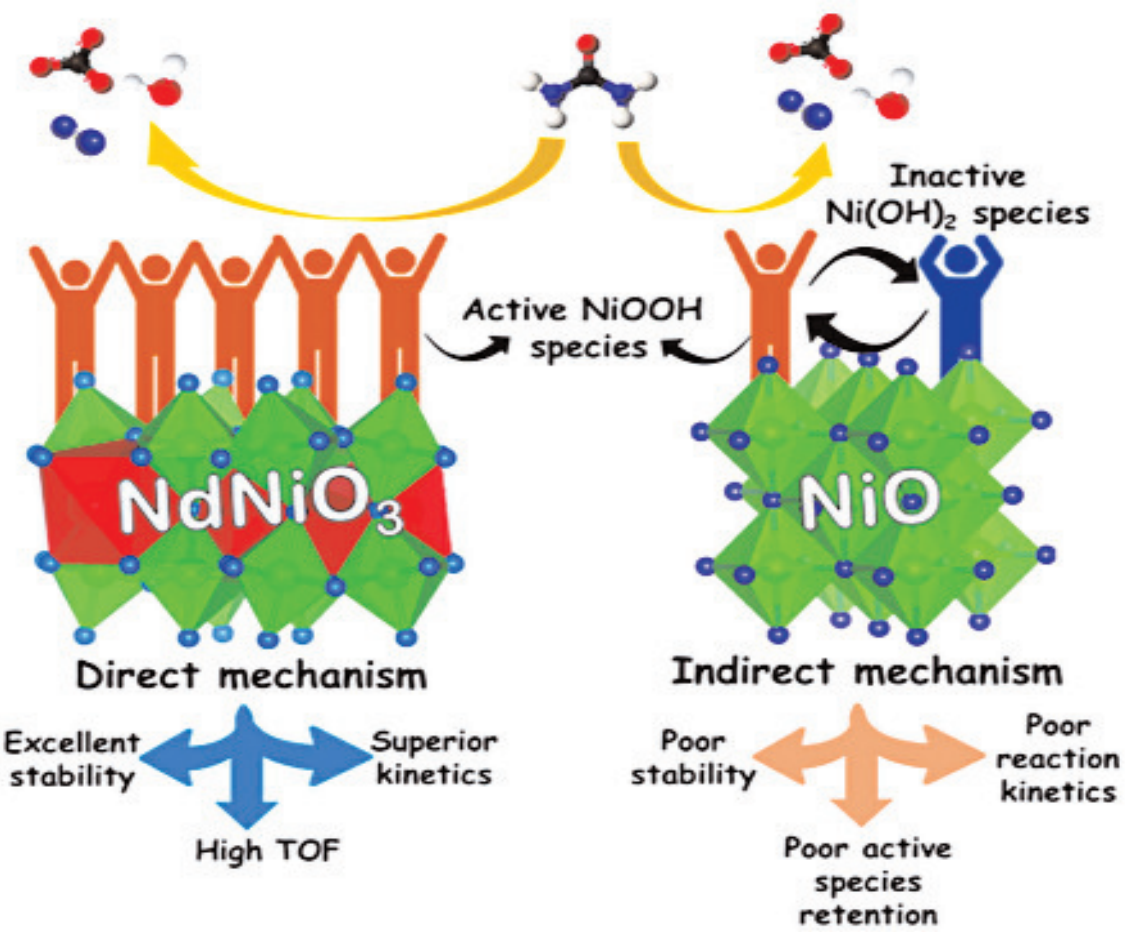
The compound's name, Yb doped AgSbTe2, refers to the crucial doping of Yb, an isovalent dopant, into the AgSbTe2 compound. This doping process ensures an optimal concentration of charge carriers, preventing disruptions in electron transport.

The material is designed to act as a glass in terms of heat transport, effectively blocking heat waves, while simultaneously behaving like a metal when it comes to the conduction of electrons or charge carriers. This dual functionality opens possibilities for energy efficiency, particularly in the field of thermoelectric energy conversion. The research team achieved this feat by introducing embedded intrinsic nano-structures within the compound. These nano-structures, existing in dimensions on a nano-scale, proved to be exceptional heat blockers, selectively allowing the passage of electron waves.

To elaborate on the significance of this discovery, Prof. Biswas drew an analogy with everyday metals like copper. "While metals such as copper are excellent conductors of both electricity and heat, the newly synthesised material defies this norm by exhibiting metal-like conductivity for electricity but glass-like behaviour for heat, which is a rare and fascinating result." The implications of this research extend into the realm of thermoelectric energy conversion, where waste heat from various sources, such as industrial processes in power plants, households and vehicle exhausts, can be harnessed and converted into electricity. This breakthrough has the potential to significantly improve energy efficiency and sustainability.

They have made a proof-of-concept type two-leg device with a material of efficiency ~9 per cent. However, the current challenge remains in scaling up the device for practical applications. Prof. Biswas says, "The semiconductor industry plays a crucial role in this process, and we need a robust semiconductor industry, a sort of semiconductor revolution, in India to drive the mass production of devices based on this revolutionary material. Industry support is crucial to translate the fundamental science research into practical application."

Looking ahead, Prof. Biswas and his team envision further advancements in the field, aiming to create materials with even higher thermoelectric efficiency. Additionally, understanding the chemical bonding and inner structures of materials remains a key focus for future research, with ongoing collaboration with synchrotron facilities for in-depth analysis. The potential applications in energy conversion and sustainability make this breakthrough a significant step forward in the quest for cleaner and more efficient energy solutions.



New catalyst enhances efficiency in hydrogen production

Scientists have identified a new catalyst that can efficiently oxidise urea and lower the energy demand for hydrogen generation by urea-assisted water splitting, thereby making way for improved production of the green fuel. Understanding the importance of hydrogen energy in reversing climate change, the scientific community is intensifying efforts to revolutionise hydrogen production, a key player in the clean energy landscape. Electrolytic generation of hydrogen at cathode, while inherently clean and green, has been hampered by the energy demands of the oxygen evolution reaction at the anode (counter electrode). A viable solution emerges from replacing the oxygen evolution reaction with other anodic processes such as urea electro-oxidation reaction (UOR) possessing lesser overall cell potential. By adding urea to water, it has practically been shown to reduce the energy demand for electrochemical hydrogen production by about 30 per cent. This not only reduces the electrical energy input and hence, the cost for hydrogen generation from water but also holds a promise for remediating urea from wastewater in conjunction with energy generation while converting urea into nitrogen, carbonate, and water.

A team of scientists from Centre for Nano and Soft Matter Sciences (CeNS), Bengaluru, Mr. Nikhil N. Rao, Dr. Alex Chandraraj and Dr. Neena S. John, have demonstrated a non-noble metal catalyst, Ni^{3+}-rich, Neodymium Nickelate ($NdNiO_3$) with metallic conductivity that efficiently oxidises urea, thereby lowering the energy demand for hydrogen generation by urea-assisted water splitting.

The investigation was taken up as part of an ongoing project to develop high-active and tolerant catalysts based on high-valent Ni-oxides for urea electrolysis, which is supported by the erstwhile Science and Engineering Research Board (SERB), now ANRF. The team used neodymium nickelate as an electrocatalyst for UOR, and using techniques such as X-ray absorption spectroscopy, electrochemical impedance spectroscopy, and Raman spectroscopy performed operando (under operating conditions), substantiated that the catalyst drives the reaction specifically through a 'direct mechanism'. The direct mechanism exhibited by electrochemically activated neodymium nickelate stands out for its minimal catalyst degeneration and reconstruction, contrasting with the indirect mechanism requiring regeneration after each cycle of UOR that prevails in Ni^{2+}-rich catalysts such as NiO. The catalyst has superior reaction kinetics (making the reaction faster), and enhanced stability during prolonged electrolysis, which are the attributes of a good electro-catalyst.

Towards addressing the challenge posed by COx poisons, which are known for deactivating UOR catalysts and compromising their long-term electrolysis durability, neodymium nickelate emerges as a promising solution. Its exceptional tolerance to COx poisons endows it with notable electro-catalytic stability. Computational calculations in collaboration with Dr. Moumita Mukherjee and Prof. Ayan Datta from Indian Association for the Cultivation of Science (IACS), Kolkata, validate the experimental findings.

Published in *ACS Catalysis*, a journal dedicated to publishing experimental and theoretical research on catalytic materials, this work could direct future studies aiming to enhance the number of NiOOH species and stabilise these species on Ni^{3+}-rich substrates. The goal is to achieve improved performance with low mass loading of active Ni in the catalyst, marking a significant step towards sustainable and efficient hydrogen production.

An innovative way to convert carbon dioxide into ethylene

Researchers have synthesised a novel and highly efficient photo-catalyst that can convert carbon dioxide to high value products like ethene and ethylene which are used as fuel gases and also for the polymer industry. The innovation has been scaled up and has received national and international attention.

In the run up towards a sustainable future, harnessing solar energy for fuel production is crucial. In this context,

(Researchers team) Credit: Deemerwha studio from Shutterstock)

efficient photo-catalysts are needed for catalysing the conversion of solar energy to fuel. These photo-catalysts can, in fact, efficiently generate useful and high-valued products from carbon dioxide (CO_2), which is important for solar fuel production. Now, while recent developments have yielded some beneficial results towards this goal, materials for photo-catalytic CO_2 reduction reactions with selectivity towards such high-valued products are still in the early stages of development.

To this end, Professor Sebastian C. Peter, a material scientist from Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru (an autonomous institution under the Department of Science & Technology, Government of India), has recently conducted a groundbreaking investigation. He undertook two interconnected studies with industry-academia collaboration. The findings of these studies were published in the *Journal of the American Chemical Society* (JACS) and Angewandte Chemie International Edition, respectively. The JACS study led to the development of a novel and highly efficient photo-catalyst with an unprecedented selectivity of 99 per cent toward C_2H_4, a typically high-value product obtained from CO_2. Moreover, the Angewandte study reports the facile synthesis of the wurtzite phase of $CuGaS_2$, a photo-catalyst for CO_2 reduction reaction, by colloidal synthesis.

The composite catalyst developed in the JACS study demonstrates highest formation rate in the field of photo-catalysis. The research also introduces a template-free and cost-effective synthetic strategy for the development of the composite catalyst. This not only emphasises practicality and cost efficiency, but also suggests a potentially scalable approach for large-scale applications. In the Angewandte study, the wurtzite phase of the photo-catalyst undergoes in situ surface reconstruction under specific conditions. This reconstruction process ultimately facilitates the selective conversion of CO_2 to ethylene. Prof. Peter's work focusses on developing, discovering, and scaling up materials with a keen focus on applications in the energy and environmental sectors. One significant area of his research involves utilising various pathways, such as high-pressure and high-temperature conditions or harnessing electricity, to convert captured CO_2 into valuable chemicals and fuels. In his pursuit of green technologies, he has ventured into utilising sunlight to convert CO_2 and water into various valuable compounds beyond methanol. This innovative approach, combining chemistry and chemical engineering, demonstrates the depth of Prof. Sebastian's exploration into the structural nuances of catalysts.

This recent breakthrough by JNCASR scientists has facilitated the development of the country's first plant that can convert CO_2 into methanol. This involves connecting directly to flue streams from a power generation plant in the state of Telangana. By capturing CO_2 from polluted air emissions and producing onsite hydrogen, they aim to convert one ton of CO_2 per day into methanol.

Talking about these developments, Prof. Sebastian says, "The catalysts we have developed have not merely remained confined to the laboratory. In fact, we have successfully scaled up our innovations, with a dedicated building within the other JNCASR campus serving as the epicentre for large-scale demonstrations. These demonstrations have garnered attention from national and international agencies, including our participation in the prestigious NRG COSIA Carbon XPRIZE, where our technology received ISO certification." This research was supported by the Department of Science and Technology, Council of Scientific & Industrial Research (CSIR), Nanotechnology Platform Program of the Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT), the European Synchrotron Radiation Facility (ESRF), light source PETRA III at DESY, and JNCASR.

Cost-effective technology to capture CO_2 from industrial wastewater

A Mumbai-based start-up has developed an aqueous-based CO_2 capture technology comprising a new catalyst that is robust, cost-effective, and scalable. This technology has the capability to capture CO_2 in industrial wastewater, marking a significant milestone in the country's transition towards climate-friendly technologies.

The innovation emerged from research work at the Department of Science and Technology (DST) supported National Centre of Excellence in Carbon Capture and Utilisation (NCoE-CCU) at IIT Bombay. The Technology Business Incubator (TBI) of IIT Bombay (Society for Innovation & Entrepreneurship - SINE) nurtured the UrjanovaC, which was fueled by a vision to revolutionise clean energy solutions.

The DST-supported National Centre of Excellence in Carbon Capture and Utilisation (NCoE-CCU) at IIT Bombay has been at the forefront of developing cost-effective CO_2 capture and conversion solutions. In efforts to support India's goal for net-zero emissions by 2070, the National Center is actively working towards developing novel, scalable, and affordable pathways for capturing CO_2 from various emission sources and converting it into valuable chemicals or permanent storage, representing a crucial pathway for greenhouse gas mitigation.

DST also established the TBI (SINE) at IIT Bombay along with many others in academic/technical/R&D institutions as part of the NIDHI programme to support and nurture knowledge-driven innovative start-ups into successful enterprises.

The DST provided UrjanovaC access to a network of seasoned mentors and advisors who brought invaluable industry insights and guidance to UrjanovaC's leadership team. They also offered strategic advice that accelerated UrjanovaC's growth trajectory and facilitated networking opportunities.

UrjanovaC's award-winning technology can capture CO_2 from both industrial flue gas and ambient air in the presence of water, which can be industrial wastewater or even seawater.

It relies upon earth-abundant elements along with non-potable water to pave the pathway for a sustainable carbon management process implementable for multi-billion-ton CO_2 removal. The captured CO_2 can be subsequently converted to high-value minerals while the catalyst gets recycled. It will ensure efficient capture of CO_2 to permanently fix them as stable mineral carbonates, thereby providing a sustainable CCUS technology.

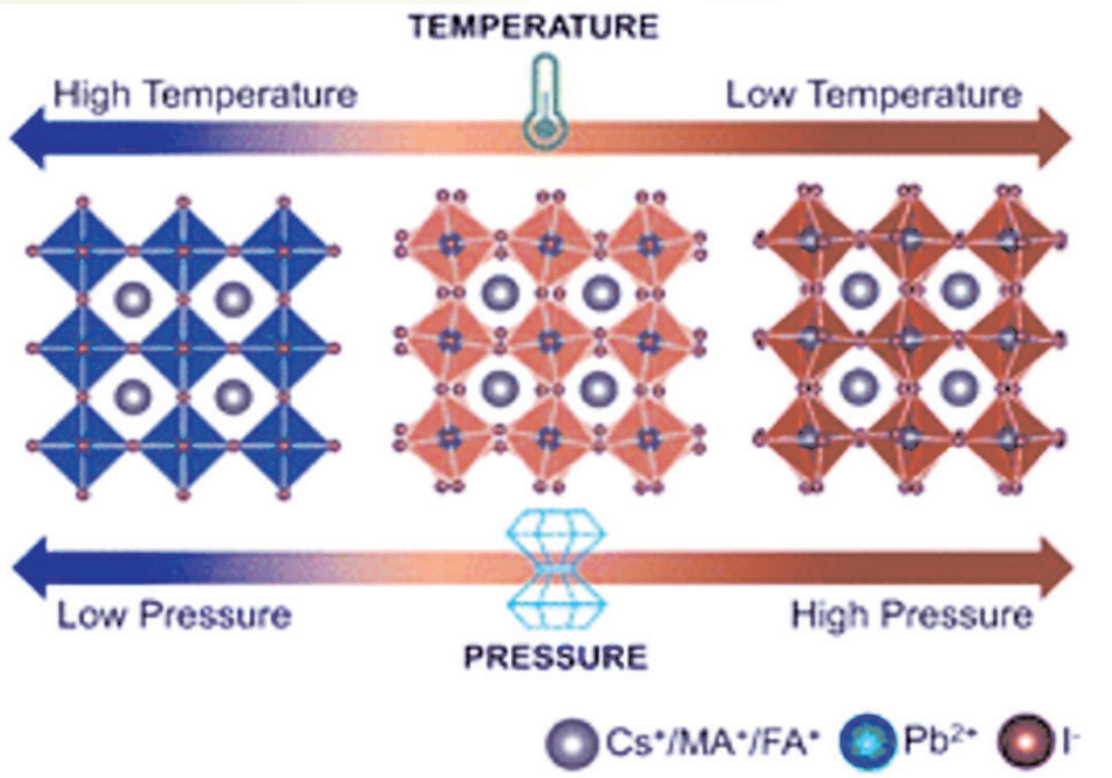
The founders, Prof. Vikram Vishal and Prof. Arnab Dutta, both faculty members at IIT Bombay, were

inspired to generate energy with a minimal carbon footprint by the pressing need for efficient CO_2 management technologies.

Their brainstorming sessions led to the conceptualisation of an integrated and innovative approach to mitigate this problem. The technologies being pursued by UrjanovaC have received multiple recognitions such as the CCS X-Prize, supported by the Elon Musk Foundation, the Arcelor Mittal's X-Carb™ finalist, and the Open-Air Collective Carbon-Dioxide Removal (CDR) Prize. The system can be widely employed in the energy sector of the upcoming smart cities to lay the blueprint for carbon footprint-free power generation and provide solutions for reducing CO_2, a major greenhouse gas. It is an environment-friendly solution that can also reduce slag and waste in industries like steel, cement, and chemicals.

The patented technology, which is at TRL 5, will significantly help industries to minimise their carbon footprint without compromising their production capacities. Apart from being an eco-friendly process, the technology also decarbonises faster than any other in-market technology and produces valuable end products that can be further used by industries as a waste-to-wealth solution. The team is currently focussing on the deployment of their first three-tonne-per-day CO_2 capture pilot at IIT Bombay. With technology as well as commercial partners like the National Center of Excellence in Carbon Capture and Utilization, Sprih, SINE, GDC at IIT Madras, Abhitech, and Venture Centre, the team is scaling up the technology rapidly.

The scalable and commercially viable solution could create multiplicative macro and micro-economic opportunities, including job creation, growth of the CCUS market, as well as strategic alliances. Besides, the end products of this CO_2 capture technology are high-value minerals like carbonates, which is itself a multi-billion-dollar industry.



Researchers conducted a comprehensive review to understand the possible phase transitions of iodide perovskites (Credit: *Journal of Materials Chemistry A*)

Study on structural transitions in hybrid perovskites helps renewable energy generation

A study by Bharat Ratna Professor C.N.R. Rao and his team has explored precise atomic rearrangements that occur in each phase transition of lead iodide perovskites due to altered temperature and pressure and their resulting effects on optoelectronic properties. Such studies could help in efficient renewable energy generation.

In recent years, lead iodide perovskites have attracted much attention, thanks to their astonishingly good opto-electrical properties which make them excellent solar cell materials. While their energy conversion efficiency can be higher than even that of commercial silicon-based solar cells, lead iodide perovskites are not inherently stable materials. Studies have reported that these materials undergo different structural changes (or 'phase transitions') even under similar conditions. Temperature and pressure shifts can easily modify their crystalline structure, altering their physical properties and lowering their performance.

An in-depth analysis of their reported phase transitions was therefore essential to understand the current limitations of these materials and get on track toward potential solutions.

In a new study, Professor Pratap Vishnoi and Professor C.N.R. Rao from Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR) Bengaluru, an autonomous institution under the Department of Science & Technology have reviewed the current knowledge gaps and recent progress on hybrid lead iodide perovskites. The study was published in the Royal Society of Chemistry's *Journal of Materials Chemistry A* and was supported by a Ramanujan Fellowship by the erstwhile Science & Engineering Research Board (SERB), now ANRF.

Prof. Vishnoi and Prof. Rao reviewed over a hundred publications of existing literature on the reported phase transitions and crystal structures. They focussed on the results of these studies and the experimental methodologies used by their authors. This approach highlighted the strengths and limitations of the commonly employed techniques, such as X-ray and neutron diffraction. The researchers also touched on the topic of chemical instability in lead iodide

Prof. Vishnoi and Prof. C.N.R. Rao

perovskites, specifically, how and why these materials decompose when exposed to humid air.

One of the main motivations for undertaking this comprehensive review was the huge potential of these hybrid perovskites for commercial applications, primarily due to their varied and unique crystalline structures. The researchers wanted to know the precise atomic rearrangements that occur in each phase transition and how these changes could lead to degraded stability in solar cells and other practical applications.

Notably, the phase transitions induced by temperature and pressure can be quite different in these materials. Thus, two separate main sections were dedicated to exploring the nature of these transitions as sources of instability, highlighting their underlying mechanisms, and their resulting effects on optoelectronic properties.

Further studies on lead iodide perovskites, as well as other types of hybrid perovskites, will hopefully lead to more efficient renewable energy generation. If their instability problems can be efficiently addressed, they could make for great materials for solar cells, since they can be processed into thin films. Other notable use cases are colour LEDs and X-ray shielding in research and medical facilities. Moreover, they may be a clever way to take advantage of phase transitions to store and transport energy. When certain phase transitions occur, some of the energy accumulated in the previous configuration is released as heat. This could be useful for developing thermal energy storage systems, contributing to sustainable energy solutions.

Excited about the possible future in this field, Prof. Vishnoi concludes by saying, "Our perspective is expected to raise the current level of understanding of structures at the atomic level and provide some new strategies to further design and synthesise stable iodide perovskites."

(DST Media Cell)

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International symposium on technology transfer

Commercialising Intellectual Property for a Sustainable Future

Cmde. Amit Rastogi (Retd.), CMD, NRDC addressing the symposium

Participants attending the symposium

National Research Development Corporation (NRDC), in strategic collaboration with United States Patent and Trademark Office (USPTO), the Department for Promotion of Industry and Internal Trade (DPIIT), the Cell for IPR Promotion and Management (CIPAM), Karnataka State Council for Science and Technology (KSCST) and the Cambridge Institute of Technology (CIT), Bengaluru successfully organised an international symposium on technology transfer, 'Commercialising Intellectual Property for a Sustainable Future'.

The symposium was organised on 14 March 2024 and served as a premier platform for multidisciplinary stakeholders, including scientists, technocrats, government policymakers, industry executives, IP professionals, MSMEs, start-ups, and academic leaders, to convene and discuss strategies for driving innovation and technology transfer in green technologies for a sustainable future.

Addressing critical themes such as global collaboration opportunities, innovation ecosystems facilitating technology transfer, IP and technology management strategies, and the indispensable role of start-ups in advancing green technology initiatives, the symposium provided valuable insights into the latest trends and best practices in technology transfer.

Ms. Kathi Vidal, United States Under Secretary of Commerce for Intellectual Property and Director USPTO's address focussed on promoting IP culture, encourage start-ups, green technologies, women entrepreneurs, etc. which will be way forward to harness technologies in a sustainable manner. Cmde. Amit Rastogi (Retd.), CMD, NRDC in his talk proposed an Indo-US joint venture partnership programme for the establishment of a model National Technology Transfer Organisation in India. Throughout the event, compelling case studies highlighted successful endeavours in innovation, technology transfer, and IP commercialisation, with a special emphasis on green technologies. These case studies demonstrated tangible outcomes and real-world impact, inspiring participants to harness the power of innovation for sustainable development. By leveraging the collective expertise and resources of both the nations, the symposium discussed ways to accelerate the pace of innovation and technology transfer towards a greener and more sustainable future.

Furthermore, the symposium facilitated collaboration and partnerships with several stakeholders. On the occasion, MoUs

were exchanged with Karnataka State Council for Science and Technology (Bengaluru), Vellore Institute of Technology, Andhra Pradesh and Cambridge Institute of Technology (Bengaluru). The symposium also witnessed handing over of TDVC Agreement with the beneficiary; technology license agreements with M/s Manikstu Agro Pvt. Ltd. and M/s. Sun Teknolozy Pvt. Ltd. handing over of Seed Funding Agreement to M/s. Foresight Biotech Pvt Ltd and launch of the Roshni Lantern manufactured by an NRDC licensee, M/s. Yallas Technologies Pvt. Ltd. The deliberations of the symposium underscore commitment to foster a robust ecosystem for innovation, entrepreneurship, and sustainable development. As the nation continues to prioritise green technologies, initiatives like these play a crucial role in driving India towards a more sustainable and prosperous future.

Exchange of MOU between Prof. Rajeev Ahuja (second from right) from the Indian Institute of Guwahati and Shri Abinash Kumar (first from left) exchanging the MOU on behalf of Cmde. Amit Rastogi (Retd.) CMD, NRDC from NRDC in an online mode, in the presence of other senior officials

IIT Guwahati and NRDC forge alliance to fuel innovation and economic growth

The Indian Institute of Technology Guwahati (IITG) and the National Research Development Corporation (NRDC), under the Department of Scientific & Industrial Research, Ministry of Science & Technology, solidified their collaboration with the signing of a Memorandum of Agreement (MoA) on 6 March 2024.

Under the leadership of Cmde. Amit Rastogi (Retd.) from NRDC and Prof. Rajeev Ahuja of IITG, this strategic partnership aims to drive transformative changes and bolster economic growth through technological advancements. With a keen focus on nurturing the regional ecosystem and fostering dynamic research, the collaboration pledges to promote, develop, and commercialise innovative technologies.

The signing ceremony, attended by senior officials from NRDC including Shri N.G. Lakshminarayan, Shri Amitabh Mishra, Shri Subodh Chawla, Dr. B.K Sahu, and Shri R. Gondane, along with esteemed representatives from IIT Guwahati, Prof. Vimal Katiyar and Prof. Subhendu Sekhar Bag, was marked by insightful discussions led by CMD NRDC. The discussions underscored the pivotal role of technology transfer in driving innovation and progress.

NRDC exchanges technology transfer agreements with Unised Research Consultants Pvt. Ltd.

On National Science Day, the National Research Development Corporation (NRDC) announced a landmark collaboration with Unised Research Consultants Pvt. Ltd., signing four crucial technology transfer agreements aimed at combatting India's pervasive malnutrition crisis. These agreements signify a pivotal step in harnessing the innovative food technologies developed by CSIR-Institute of Himalayan Bioresource Technology

NRDC officials signing four technology transfer agreements with Unised Research Consultants Private Limited

(CSIR-IHBT), Himachal Pradesh. The cutting-edge solutions include iron and zinc enriched Spirulina-based bars, protein and fibre enriched cereal bars, multigrain protein mixes, and iron enriched fruit bars. With features such as proven effectiveness, absence of preservatives or additives, affordability, and extended shelf life, these technologies are poised to make a significant impact in addressing malnutrition, aligning with both the UN's goal of ending hunger and India's National Nutrition Mission.

NRDC receives 'Investment in Start-up Award'

The National Research Development Corporation (NRDC) has been honoured with the esteemed 'Investment in Start-up Award' at the 10th PSU Governance Now Awards. This recognition underscores NRDC's outstanding dedication to nurturing start-ups across the nation.

The award ceremony, held at Holiday Inn, Aero City, New Delhi, witnessed the presence of eminent dignitaries and stakeholders from the public sector. Cmde. Amit Rastogi (Retd.), CMD of NRDC, along with senior officials, accepted the accolade, symbolising the organisation's unwavering commitment to fostering innovation and entrepreneurship in India. Speaking on the occasion, Cmde. Amit Rastogi (Retd.) expressed gratitude for the recognition, emphasising NRDC's ongoing efforts to support and empower start-ups in various sectors. He reiterated NRDC's mission to catalyse economic growth through technology transfer, incubation, and investment in emerging ventures.

The 'Investment in Start-up Award' bestowed upon NRDC underscores its pivotal role in facilitating the growth and success of start-ups, thereby contributing significantly to India's journey towards becoming a global hub for innovation and entrepreneurship. The PSU Governance Now Award serves as a testament to NRDC's exemplary contributions to the start-up ecosystem and reaffirms its position as a leading catalyst for innovation and technology commercialisation in the country.

Cmde. Amit Rastogi (Retd.), CMD, NRDC addresses ongoing efforts taken by NRDC to support and empower start-ups across various sectors

Dibrugarh University and NRDC join hands to foster innovation

In a momentous step towards fostering innovation, Dibrugarh University and the National Research Development Corporation (NRDC) signed a Memorandum of Agreement (MoA) on 5 April 2024. The MoA, facilitated under the Department of Scientific & Industrial Research, Ministry of Science & Technology, signifies a significant stride in nurturing innovation in the region.

The signing ceremony was led by Cmde. Amit Rastogi (Retd.), CMD of NRDC and Prof. Jiten Hazarika, Vice-Chancellor of Dibrugarh University. Notable attendees from NRDC included senior officials Shri Amitabh Mishra, Shri Subodh Chawla and Dr. B.K. Sahu. The esteemed presence of Dr. Paramananda Sonowal, Registrar of Dibrugarh University, along with Dr. Pankaj Chetia, Associate Professor and Secretary of the IPR Cell, and Dr. Abhijit Boruah, Assistant Professor, emphasised upon the commitment of the university towards fostering innovation. The signing event was followed by an insightful discussion highlighting the pivotal role of technology transfer in driving progress. With this collaboration, both the institutions are poised to embark on impactful partnerships and drive innovation-driven progress in the region.

Cmde. Amit Rastogi (Retd.), CMD, NRDC highlights NRDC's pivotal role and technological services in the ecosystem at MIG SMARTECH Conclave in Pune

SMARTECH Conclave highlights NRDC's contribution in the technology ecosystem

On 6-7 March 2024, the National Research Development Corporation (NRDC) took centre stage at the SMARTECH Conclave held in Pune, where it highlighted its significant contribution to the technology ecosystem. Cmde. Amit Rastogi (Retd.), CMD, NRDC participated in the event, presenting a comprehensive overview of NRDC's role and services. Participating industries and start-ups demonstrated a palpable interest in understanding and leveraging the array of services offered by NRDC. The corporation's presentation elucidated its pivotal role in facilitating technology transfer, innovation, and commercialisation across various sectors. The event served as a platform for stakeholders to engage with NRDC representatives, fostering collaborations and partnerships aimed at harnessing technological advancements for societal benefit. NRDC's presence at the SMARTECH Conclave underscored its commitment to driving innovation and fostering a vibrant technology ecosystem. As industries and start-ups continue to explore avenues for growth and development, NRDC remains steadfast in its mission to catalyse technological innovation and propel India towards becoming a global leader in research and development.

(Compiled by NRDC officials)

Department of Scientific and Industrial Research

Ministry of Science & Technology
Govt of India

Innovative Technologies in Sericulture Sector Available for Transfer & Commercialisation

NRDC, a premier Technology Transfer Organisation under Department of Scientific & Industrial Research (DSIR), Ministry of Science & Technology, Govt of India with over more than 2000 innovative technologies available for transfer and commercialisation to MSMEs, Start-ups & industries under Make in India.

'' Silk Samagra''- Sericulture Technologies for Social Entrepreneurship Development

- Azoto Bacteria Biofertiliser
- Biofungicides
- Reshmjyothi
- Reshmkeetoushadha
- ANKUSH -A New Silkworm Bed Disinfectant
- AMRUTH–A Botanical Product for Controlling Grasserie and Flacherie in Silkworm
- SPOORTHI – Mulberry Leaf Health Drink
- VIJETHA-Silkworm Bed Disinfectant
- NUTRID – Artificial Diet for Silkworms
- NAVINYA – A Plant based Formulation for Control of Mulberry Root Rot Disease
- POSHAN – A Multinutrient Formulation for Correcting the Nutrient Deficiencies in Mulberry
- ABHAYA – A Process of Manufacturing Plant Based Anti-Viral Formulation for Silkworms

& many more such technologies

FOR OBTAINING LICENSE OF THE TECHNICAL KNOW-HOW, PLEASE CONTACT:

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MOBILE COLD MIXER CUM PAVER

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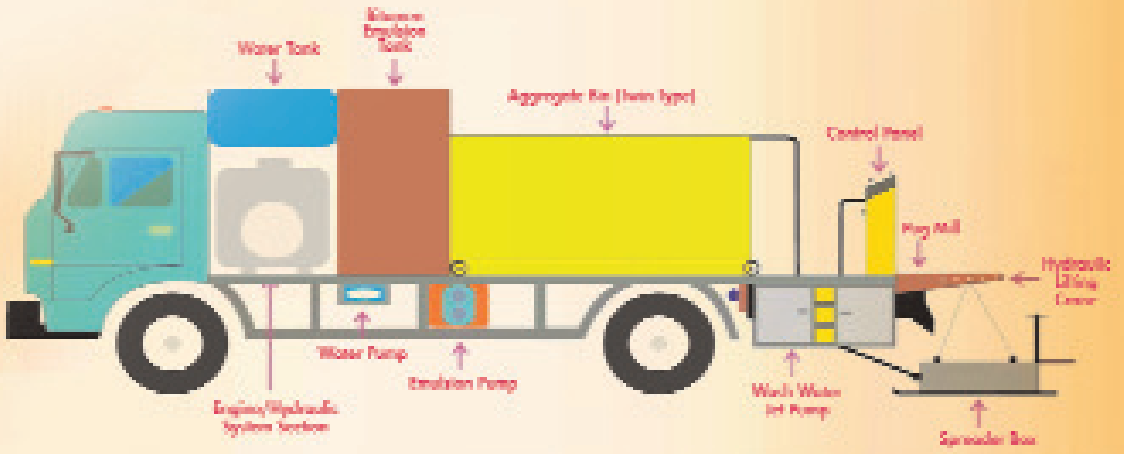

APPLICATIONS

Construction of pavement, roads in the high altitude and remotely located hill sites, narrow lanes in villages

ADVANTAGES

The machine is low cost, compact and portable

Eases the construction and maintenance of existing road network mainly in hilly region & narrow lanes in villages

The use of bitumen emulsions eliminates heating of binder and aggregate and also prevents degradation of environment thus conserves energy

FOR MORE DETAILS: ASHWANI KUMAR (AM), E-mail: ashwanik@nrdc.in | DR. A.K. SRIVASTAVA, E-mail: asrivastava@nrdc.in

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